ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF ARTS AND SOCIAL SCIENCES

THE IMPACTS OF TRANSPORTATION INVESTMENT ON TURKISH ECONOMY AT MICRO, MACRO AND REGIONAL LEVEL *IN A SPATIAL COMPUTABLE GENERAL EQUILIBRIUM MODEL FRAMEWORK*

PhD THESIS

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ULAŞTIRMA YATIRIMLARININ TÜRKIYE EKONOMISI ÜZERINE MAKRO, MIKRO VE BÖLGESEL DÜZEYDEKI ETKILERI *MEKANSAL HESAPLANABILIR GENEL DENGE MODELI KAPSAMINDA*

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FOREWORD

Writing this thesis was very interesting and challenging task, since it required different kind of data and detailed knowledge at the modelling of the first multi regional CGE model in Turkey. During last two years that I spent for this thesis, I was programmer, researcher and writer simultaneously. It is very difficult to say which of the roles I liked most. I think the time I spent as a researcher was more comfortable.

I am especially thankful to my advisor Professor Christopher Hannum. He has contributed a lot to modelling and writing parts of the simulations. The most important thing, however, is that he behaved like a colleague and friend during my research, which makes him the best supervisor ever.

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Other then these, any remaining errors and judgmental mistakes belong to myself.

February 2018 Metin PISKIN
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ABBREVIATIONS

CGE	: Computable General Equilibrium
SAM	: Social Accounting Matrix
MRSAM	: Multi Regional Social Accounting Matrix
SNA	: System of National Economic Accounts
PSGE	: Public Sector General Equilibrium
BoP	: Balance of Payments
ROW	: Rest of the World
GNI	: Gross National Income
GDP	: Gross Domestic Product
NUTS	: Nomenclature of Territorial Units for Statistics
CB	: Commodity Balance
LQ	: Location Quations
CHARM	: Cross Hauling Adjusted Regionalization Method
CES	: Constant Elasticity of Substitution
MPSGE Analysis	: Mathematical Programming System for General Equilibrium
GAMS	: General Algebraic Modeling System

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THE IMPACTS OF TRANSPORTATION INVESTMENT ON TURKISH ECONOMY AT MICRO, MACRO AND REGIONAL LEVEL *IN A SPATIAL COMPUTABLE GENERAL EQUILIBRIUM MODEL FRAMEWORK*

SUMMARY

The role of infrastructure in national and regional economic development is critical in developing countries like Turkey. Because transportation costs are still largest component of doing business. Especially, less developed eastern regions of Turkey face higher transportation costs than the coastal and western regions (World Bank, 2012). Any additional investment to road network will contribute to lower transportation costs, since road transport is still the primary mode of freight transport in Turkey (It accounts for about 90 percent of domestic freight and passenger traffic). In this regard, Turkey has quadruplicated its divided road stock from only 6040 km in 2002 to 23831 km in 2016. Total highways length increased from 1714 km to 2542 km at the same time interval.

Government's plans include the tripling of the country's highway length from around 2,500 km to 7,500 km by 2023 (100th anniversary of the Republican Turkey) at the different route connecting west to east and north to south without discriminating any regions. Since transportation investments are many sided and complex, the aim of this thesis is to analyze the outcomes from highway projects for the period 2017-2023, proposed by the General Directorate of Highways in Turkey within a Spatial Computable General Equilibrium Model framework.

There exist many kind of studies that evaluate the economic contribution of infrastructure investments to economic growth following a neo-classical approach by measuring the economic output elasticity of infrastructure (Chen and Haynes, 2015). However, this kind of econometric analysis can only evaluate the relationship between economic growth and infrastructure. The indirect impact as a result of demand change can not be captured in a regression framework since these kind of analysis is evaluated from the supply side; i.e., it is assumed that demand is constant during the investment.

On the other hand, it is helpful to be able to deal with models in which space and distance enters in the scene, if location and space considered as an important argument in the science of economics (Krugman, 1998). Since transport investments are location specific and economic activities is closely connected with transportation costs, we need to work with a model which will incorporate the dimension "space" into analysis.

Spatial Computable General Equilibrium (CGE) models exactly fits our needs. In a General Equilibrium model framework, all prices and quantities at the market react to the primary cost change resulting from an infrastructure investment and changes in cost reductions eventually show up in income and the utility of private households and affect the production decision of firms. In this sense, any cost change in transportation side of the economy will effect general equilibrium of the economy. New highways in different regions will effect the prices via cost changes in transportation margins and consequently interactions between regions at different levels. Here, household's utility which is translated to a monetary index is the key criteria of this kind of analysis (Bröcker, 2006). So, one of the main focus will be the spatial distribution of welfare effects.

To best of our knowledge, any application for Turkey at spatially disaggregated level

and the proposed modelling approach has not been applied before. So, one of the key steps of this thesis is to build a multi-regional CGE model and its database, namely, multi-regional Social Accounting Matrix (MRSAM). Based upon this structure of Social Accounting Matrix which is database of CGE models and the modelling framework, this thesis brings an effective tool to analyze the effects of different policies in Turkey at spatial level.

In this regard, building a multiregional Social Accounting Matrix for Turkey in a proper way with the available data was introduced in this thesis. Computable General Equilibrium (CGE) models require comprehensive data to produce quantitative results. A Social Accounting Matrix (SAM) provides the underlying data framework for this type of models. According to this, SAM structure a consistent data framework which includes input-output data and national, household and government income accounts in a consistent way. The availability of regional employment data from Social Security Institute, interregional trade flows data from Ministry of Science, Industry and Technology and lastly various kind of regional data from TurkStat are permitting us to extend national level Social Accounting Matrix (SAM) to Multi-Regional SAM.

On the modelling side, Multi Regional Computable General Equilibrium model that we constructed in this thesis constitutes of 11 regions. In each region, final demand structure is composed of public and private expenditure and also demand for investment across goods. Since this is a spatial model, decisions about the allocation of resources are decentralized, and the representation of behavior by representative agents in the region such as households or regional investment follows the standard microeconomic optimization framework. According to this, consumers will maximize welfare subject to a budget constraint and producers will combine intermediate inputs with labor and capital at least cost for a given technology.

Experiments are simulated by changing the trade and transportation margins according to a network model. Route choice between two nodes based on shortest distance in the network. The thing here we need to emphasize is that any improvement between two nodes at the network has many sided. Distance shortening between two cities will also affect the distance between other related cities. So, any decrease between two nodes at the network will change the route from one region to another and will cause positive spill-over effect in network.

According to these spillover effect in the transportation network, model results indicates that all regions for all scenarios experience an increase in welfare and regional efficiency (Gross Domestic Product). Intuition behind this result is that any enhancement in transportation network will reduce the cost of production in the transportation sector which will be affected by new highway project. And transportation sector as a margin industry will reduce the production cost of other industries through their transportation cost component. This cost reduction will increase the marginal productivity of labor and capital, making it profitable to demand more labor and capital from the initial levels of prices. And at the end of the day, household which own these primary factors will generate more income since increased demand for capital and labor will increase the real prices of hiring these production factors

Regarding the impacts of new highway projects on household welfare in different regions, our model outputs indicate that households in less developed regions with better access to economically bigger cities appear to be better off. The mechanism behind this inference based on the fact that lower transport cost results in a greater volume of goods being available at lower prices in less developed cities by bringing nearer these farther regions to the richer regions. In that sense, big cities like Istanbul, Izmir and Ankara experience less welfare gain and efficiency enhancement. For instance, Marmara region appear to gain more then Istanbul and also Aegean region which is neighbor of Izmir gains more then Izmir in the first experiment which covers Istanbul-Izmir highway project. This fact appears also in our other two experiments.

From the same perspective, the first and second group of targeted highway packages which covers the projects subsequently in West and East of Turkey, new highway corridors can lead to substantial gain in GDP and reduction in regional income disparity according to our model results. For instance, first group of targeted highway projects which covers the new connections mainly between Aegean and Central Anatolia with Izmir-Ankara highway project and also Ankara-Nigde highway project which South East region enables access to inland and western regions, Aegean and Central Anatolia regions are outstanding in this experiment. And also third experiment reveals the same result. Relatively poorer cities in South East region benefit more than the richer ones in relative terms since eastern cities experience an increase in accessibility with the new routes.

In sum, the results demonstrate the ability of capturing regional impacts of these kind of models. And the results suggest that increased productivity of transportation services may also contribute more to some regions which gets closer to richer cities and regions, while having a positive aggregate impact on the overall economy.

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ÖZET

Türkiye gibi gelişmekte olan ülkelerde ulaştırma altyapısının bölgesel ve ulusal ölçekteki iktisadi kalkınmaya etkisi kritik öneme haizdir. Çünkü ulaştırma maliyetleri Türkiye gibi ülkelerde iş yapma noktasındaki maliyetlerin büyük kısmını teşkil etmektedir. Özellikle daha az gelişmiş Türkiye'nin doğu bölgeleri batı ve kıyı bölgelerine göre daha yüksek ulşatırma maliyetlerine maruz kalmaktadır (Dünya Bankası, 2012). Türkiye'de karayolunun hala ilk ulaştırma yolu olduğu gözönüne alındığında karayolu ağına yapılacak ilave yatırımların ulaştırma maliyetlerinin düşmesine katkı sağlayacaktır. Bu kapsamda Türkiye 2002'de sadece 6040 km olan bölünmüş yol uzunluğunu dört kat artırarak 2016'da 23831 km'e kadar çıkartmıştır. Aynı zaman diliminde otoban uzunluğunu ise 1714 km'den 2542 km'ye çıkartmıştır.

Hükümetin ulaştırma alanındaki 2023 planları ve hedefleri içerisinde farklı rotalarda farklı bölgeleri birbirine bağlayan otoban uzunluğunu üç katına yani 2500 km'den 7500 km'e çıkartma hedefi bulunmaktadır. Tam da bu noktada, Karayolları Genel Müdürlüğü tarafından 2017-2023 tarihleri arasında yapılması planlanan ve hali hazırda yapılmakta olan ulaştırma yatırımı projelerinin iktisadi etkilerinin Mekansal Hesaplanabilir Genel Denge Modeli kapsamında analiz edilmesi bu tezin amacını teşkil etmektedir.

Altyapı yatırımlarının ekonomik büyümeye etkilerini ilgili yatırımların iktisadi çıktı esnekliğini ölçerek ele alan birçok neo klasik yaklaşım mevcuttur (Chen and Haynes, 2015). Fakat bu tarz ekonometrik yaklaşımlar sadece yatırım ile iktisadi büyüme arasındaki ilişkiyi tek taraflı ele almaktadır. Yatırımların artmasıyla oluşan talep değişikliklerinde meydana gelen ekonomideki, bu analizlerin talebin yatırım boyunca sabit olduğu varsayımına dayanmasından ötürü, dolaylı etkiler regresyon analizleri kapsamında elde edilemezler

Öte taraftan, eğer konum ve mekanın önemli bir arguman olarak değerlendirildği günümüz iktasat biliminde, mekan ve mesafenin sahneye girdiği modeller ile uğraşmak yaralı olacaktır (Krugman, 1998). Ulaştırma yatırımlar mekan odaklı ve iktisadi faliyetler ulaştırma marjları ike yakın ilintili olduğundan, alan ve mekan boyutu olan modeller ile çalışmamız gerekmektedir.

Mekansal Hesaplanabilir Genel Denge Modelleri tam manasıyla ihtiyaçlarımıza uyan ve dolayısıyla bölgesel değişiklikleri detaaylı olarak analiz etmemizi sağlayan modellerdir. Genel Denge modeli çerçevesinde piyasadaki tüm fiyatlar ile üretim miktarları altyapı yatırımı sonucu oluşabilecek üretim maliyetlerindeki herhangi bir değişikliğe anında tepki vererek nihayetinde gelir ile hanehalkı fayda seviyesinde ve üreticinin üretim kararında kendini göstermektedir. Bu anlamıyla, ulaştırma sistemi makansal boyutuyla ekonomiye ulaştırma hizmetlerinin bir maliyeti olarak devreye girdiğinden, ekonominin ulaştırma kısmında oluşan herhangi bir maliyet değişikliği ekonominin tüm genel dengesini etkileyecektir. Burada parasal olarak karşılığı indexlenmiş hanehalkı faydası bu tarz analizlerdeki anahtar kriterdir (Bröcker, 2006).

Bu yüzden bu çalışmada ana odak refah etkisinin mekansal dağılımı olacaktır.

Bildiğimiz kadarıyla daha önce Türkiye için bu kapsamda mekansal ölçekte ayrıntılı ve açıklanan model tekniği kapsamında bir analiz mevcut değildir. Bu nedenle ilk adım çok bölgeli Hesaplanibilr Genel Denge (HGD) modeli ve onun ihtiyaç duyduğu çok bölgeli Sosyal Hesaplanabilir Matrisinin inşaası ilk işimiz olacaktır. İnşaa edeceğimiz Sosyal Hesaplar Matrisi'nde (SHM) kullanılan teknikler vasıtasıyla çeşitli ihtiyaçlara göre oluşturulacak bir SHM Türkiye'deki farklı iktisadi politikaların mekansal ölçekteki analizlerini mümkün kılacaktır.

Bu bağlamda varolan verileri uygun bir şekilde kullanarak Türkiye için inşaa edilecek Sosyal Hesaplar Matrisi bu tezde sunulmaktadır. Hesaplanabilir Genel Denge Modelleri yapılan simulsayonlar kapsamında sayısal bazı çıktıları sunarken çok kapsamlı ve boyutlu veriye ihtiyaç duyarlar. Sosyal Hesaplar Matrisi bu tarz model ve analizlerin veri altyapsını teşkil eden bir yapıyı sunmaktadır. Buna göre bir SHM hem girdi-çıktı hem de ulusal gelir ve üretim hesapları verilerini tutarlı bir yapıda içermektedir. Sosyal Güvenlik Kurumu'ndan sağlanan bölgesel sektör bazında istihdam verileri ile Bilim, Teknoloji ve Sanayi Bakanlığı'ndan sağlanan bölgeler arası ticaret verileri ve TÜİK'ten sağlanan farklı bölgesel ve ulusal düzeydeki üretim ve gelir verileri ulusal ölçekte inşaa edilen Sosyal Hesaplar Matrislerini çok bölgeli Sosyal Hesaplar Matrisi olarak geliştirmemize olanak sağlamaktadır.

Modelleme kısmına geldiğimizde, bu tez kapsamında geliştirdiğimiz çok bölgeli Hesaplabilir Genel Denge modelimiz 11 bölgeli bir yapıya sahiptir. Her bir bölgede, nihai talep kamu, hanehalkı ve yatırım talebinin toplamından oluşmaktadır. Mekansal bir model olduğundan kaynakların dağılımı merkezi değildir ve herbir bölgedeki temsili hanehalkının kararları ile yatırım standard mikro ekonomik optimizasyon çerçevesinde ele alınır. Buna göre tüketiciler bir bğtçe kısıtı altında refahlarını maksimize edecek üreticiler ise teknoloji seviyesi veri iken ara mal ve üretim faktörü girdilerini en düşük maliyet ile birleştirerek üretim yapacaklardır.

Bu kapsamda ticaret ve ulaştırma marjlarının yeni ulaşım yatırımları sonucu azalan mesafelerin bir network modeli kapsamında yeniden hesaplanması ile revise edilmesi ile deneylerimiz simule edilmiştir. Bu noktada altını çizmemiz gerekn husus ulaşım ağında bulunan iki nokta arasındaki mesafede meydana gelecek etkinin çok boyutlu olmasıdır. İki şehir arasındaki mesafenin kısalması network etkisi ile diğer iller arasındaki mesafeyi de etkileyecektir. Dolayısıyla bu da bölgeler arasındaki mesafelerde positif yönde *spill over* etkisine sahip olacaktır.

Ulaştırma ağındaki bu positif *spill over* etkisine göre model sounuçları tüm bölgelerin bütün deneylerimizde refah ve bölgesel katma değerdeki artış noktasında bir artış yaşayacağını işaret etmektedir. Bu sonucun arkasında yatan mekanizmayı açmamız gerekirse, ulaştırma ağındaki bir iyileşme ilgili bölgedeki ulaştırma sektörünün üretim maliyeterini düşürerek, ulaştırma sektörünün sunduğu hizmetlerin fiyatında yani ulaştırma marjındaki azalış diğer üretim yapan sektörlerdeki maliyetleri düşürerek üretim faktörlerinin marjinal verimliliğini artırmaktadır. Marjinal verimliliği artan işgücü veya sermaye daha karlı hale gelerek bu faktörlere olan talep artacaktır. Ve bu sebeple bu faktörlerin fiyatında, reel ücret ve faizlerde artış gözlenecektir. Günün sonunda bu üretim faktörlerinin sahibi olan hanehalkı daha fazla gelir elde etmiş olacaktır.

Yeni ulaştırma yatırımlarının bölgesel düzeyde hanehalkının refahına olan etkisine baktığımızda, modelimizin çıktıları Türkiye'nini daha az bölgelerindeki hanehalkının bu bölgelerin daha iyi ulaşım imkanlarıyla düşen ulaştırma maliyetleri sonucu büyük şehir ve daha gelişmiş bölgelerimize oranla refahını daha fazla artırdığı görülmektedir. Bu sonucun arkasında yatan mekanizma, daha düşük ulaştırma maliyetleriyle uzaktaki az gelişmiş bölgelerin, adeta daha yakına gelerek, görece daha zengin bölgelere yaklaşması gerçeğine dayanmaktadır. Analiz sonuçlarına göre İstanbul, İzmir ve Ankara gibi büyük şehirler görece daha az refah ve katma değer artışı yaşamaktadır. Örneğin Istanbul-Izmir otoyol projesini kapsayan birinci deneyimizin sonuçlarına göre bu hatta yer alan Marmara ve Ege bölgeleri Istanbul ve Izmir gibi büyük şehirlere nazaran en fazla refah ve üretim artışı yaşanan bölgemizdir. Buna benzer sonuçlar diğer iki deneyimizde de görülmektedir.

Aynı açıdan baktığımızda, hedeflenen birinci ve ikinci yatırım paketlerini ele alan ikinci ve üçüncü deneyimize göre, Türkiye'nin batısında doğusuna yapılacak yeni otoban koridorları gayri safi milli hasılada önemli artışlar ve dolayısıyla bölgesel gelir dağılımında önemli iyileşmelerin yaşanacağı görülmektedir. Örneğin Ege ve Orta Anadolu bölgelerini birbirne bağlayacak İzmir-Ankara otobanı ile Orta Anadolu'yu Güney Doğu Anadolu'ya bağlayacak Niğde-Ankara otobanı gibi projeleri kapsayan birinci paket yatırımları içeren ikinci deneyimizin sonuçlarına göre Ege ve İç Anadolu bölgeleri büyük şehirlerin aksine en fazla refah ve üretim artışının yaşandığı bölgeler olmuştur. Bu deneyimizde Ege ve İç Anadolu bölgeleri öne çıkan iki bölgemiz olmuştur. Yine aynı şekilde üçüncü ve son deneyimize göre de, hedeflenen ikinci gurup yatırımlar da, görece daha az gelişmiş ve fakir illerimizin olduğu Güney Doğu Anadolu bölgemiz büyük illerimize ve daha gelişmiş sanayi kentlerinin olduğu bölgelere göre oransal olarak daha fazla kazanım sağlamaktadır.

Özet olarak, sonuçlar tez kapsamında geliştirdiğimiz modelimizin mekansal ölçekte sonuçları elde edebilme kabiliyetimizin olduğunu göstermektedir. Ve sonuçlar ulaştırma sektöründeki yaşanacak maliyet düşüşlerinin, ekonominin geneline olumlu etkileri varken, bölgesel düzeyde bazı bölgelere görece daha fazla katkı sağlayacağını göstermektedir.

1. INTRODUCTION

Turkey is a success story in infrastructure investments which has done since 2001. Turkey has quadruplicated its divided road stock from only 6040 km in 2002 to 23831 km in 2016. Total highways length increased from 1714 km to 2542 km at the same time interval. Consequently, transport investments accounts for the vast majority of the increase in public investment and its share in total public investment increased from 22% in 2001 to 31% in 2015 (Ministry of Development, 2017). According to World Bank's Logistics Performance Index, Turkey is 34th of 155 countries in 2016. And also according to the World Economic Forum competitiveness report, Turkey's transport infrastructure is better than Poland's, Russia's, Mexico's and Brazil's and only moderately below the European Union average (World Bank, 2012).

On the other hand, the role of infrastructure in the national and regional economic development is critical in developing countries like Turkey. Because transportation costs are still largest component of doing business. Especially, eastern regions of Turkey face higher transportation costs than the coastal and western regions, with more than half of businesses pointing to transport as a major obstacle (World Bank, 2012). If road transport is considered as still the primary mode of freight transport in Turkey (90 percent of domestic freight and passenger traffic), there is no doubt that any additional investment to road network will contribute to lower transportation costs.

Government's targets include the tripling of the country's highway network from around 2,500 km presently to 7,500 km by 2023 (100th anniversary of the Republican Turkey) and building of over 12,000 km of new divided roads at the different route connecting west to east and north to south without discriminating any regions. No doubt, all of these efforts serve to reduce large regional economic disparities and better connect eastern and inland regions with coastal trading hubs and comparatively richer regions. Istanbul-Izmir Highway including Izmit Bay Bridge, Canakkale-Tekirdag Bridge Connection, Rize-Mardin Highway including Ovit Tunnel are only one of these projects.

All of these highway projects are so large in scale that they will have an impact on outside a single region. Because transportation cost allows economic growth to vary in different industries and regions by affecting production and consumption decisions (Ivanova, 2003). As consumption and production activities in regions are attached to each other by a transport network, any improvement in this network will enable us to see the micro, macro and regional effects of transportation investments from new bridges to new highways in different regions of Turkey.

Many of the standard econometrical approaches study the relation between new investments and economic growth which covers only impact of individual infrastructure projects on directly affected regions (Nijkamp et aI. (1984; 1987), Rietvelt (1989) and van den Bergh et al. (1995). However, none of these approaches fully captures the sort of changes in spatial level in which affects other regions' performance and overall performance of the economy. The aim of this thesis is to analyze the outcomes from new highway projects for the period 2017-2023, proposed by the General Directorate of Highways in Turkey.

Spatial Computable General Equilibrium (CGE) models exactly fits our needs and consequently allow for rather detailed analysis of regional changes. Since all prices and quantities at the market react to the primary cost change resulting from an infrastructure investment in a General Equilibrium model framework, responses in prices and quantities eventually show up in income and the utility of private households and also in the production decision of firms at the same time. Cost changes of the transport sector which is calculated by transport sub module will be the policy measure in the model. And new highways in different regions will effect the prices and consequently interactions at different levels. Since all of these interactions will be in spatial level, welfare benefit and efficiency analysis of a particular infrastructure investment package will be analyzed for each region separately. Here, household's utility which is translated to a monetary index is the key criteria of this kind of analysis (Bröcker, 2006). So, my main focus will be the spatial distribution of welfare effects.

To best of our knowledge, any application for Turkey at the spatially disaggregated level and the proposed modelling approach in this thesis has not been applied before. So, one of the first steps of this thesis is to build a database, namely, multi-regional Social Accounting Matrix (MRSAM) which has not been done before at this spatial level for Turkey. Based upon this structure of Social Accounting Matrix which is database of CGE models and the modelling framework, this thesis brings an effective tool to analyze the effects of different infrastructure projects in Turkey at spatial level.

At the remainder of this thesis, section 2 provides a review of literature in the field of CGE modeling and in particular multi-regional CGE models which focus on the transportation issues. And following section 3 describes how we constructed multi-regional Social Accounting Matrix, which is the database of the Turkish multi-regional CGE model. And then section 4 presents the Turkish multi-regional CGE model specification and transport sub module that we are going to measure changes in network after a policy scenario. Finally, section 5 illustrates spatial details of counterfactual experiments.

1.1. Spatial Nature of Transport Investments and Economic Development Connection

The effect of transport investments on economic development based on the role of transportation facilities in enabling movement of goods and activities between different regions (Weisbrod, 2007). Even in ancient times, roughly two thousand years ago, the relationship between transportation and economic development depended on producing more depended on reaching different places and consumers through transportation routes. Ancient caravan routes such as the Silk Road, the Spice Route and the Gold and Salt Route was essentially serving this purpose (Weisbrod, 2007). Only two centuries ago, US has invested freight routes for essentially the same reasons as the Romans built over 50,000 miles of paved roads to support interstate commerce routes (Weisbrod, 2007). Early federal programs supported development of highways and waterways like famous Erie Canal to expand market access for wheat and other agricultural products to be shipped from distant inland hubs like Chicago to major cities like New York (Cronon, 1991). According to famous book of William Cronon (1991), with the huge amount of railways investments, Chicago occurs as an agglomerated city in mid west of US. With the help of railways, in the long hauls, the result was a substantial drop in transportation prices and subsequently a drop in agricultural and other intermediate good prices. Also decreasing transportation costs in the continent caused a substantial rise in producers' income with the help of accessing to a wider market (Weisbrod, 2007). This picture can be very familiar to scale economies that we know today from economic theory.

All of the earliest studies in regional science recognized that concentration of economic activities in a specific location depends on access to markets (Weisbrod, 2007). Since geographic distribution of economic activities is closely connected with transportation costs, we need to emphasize these studies which incorporate the dimension "space" into analysis of the market (Capello, 2011). And this is reflected in works on development of a centralized region (Christaller, 1933), scale economies (Marshall, 1919) and agglomeration economies (Weber, 1909). And almost all of the ideas behind these theories rely on economies of scale which enforce the geographic concentration of some activities.

According to Fujita et al. (1999), agglomeration is the outcome of a "snowball effect" and within this snowball there are many factors which feeds this outcome. Natural features such as rivers or harbors could be a good geographical reasons that economies concentrate in certain locations. But from the perspective of regional science, agglomeration occurs by relying on increasing returns and the mobility costs and consequently economic growth tends to be localized (Fujita et al., 1999). Krugman (1991) asserts also high transport costs will shift the production into one core location.

On the other hand, these larger cities which the economy agglomerated will support wider range of activities. Istanbul is exactly fitted to this case. Istanbul, which has an area corresponding to around 0.6 % of the country and includes 19 % of the population, produces around 34 % of GDP. This picture also implies the existence of agglomeration at the spatial scale for Turkey.

If location is the issue and space is an important argument, it is helpful to be able to deal with models in which distance enters in the scene (Krugman, 1998). According to Krugman (1991), space or economic geography is not an important argument in economic textbooks and occupies relatively small part of standard economic analysis. For example, international trade theory treats nations as dimensionless and consequently assumes zero transportation costs between countries. At the next section, studies which pay attention to space will be discussed.

1.2. Multi-regional modeling for Transportation Analysis

Transport investments have potential growth effects on local economies. Since more aggregated analysis may cause to loose the potential impact of these investments, the analysis has to take place at the more disaggregated level (Banister and Berechman, 2001).

There exist many kind of studies that evaluate the economic contribution of new transportation projects on economic growth by measuring the economic output elasticity of infrastructure (Chen and Haynes, 2015). However, this kind of econometric analysis can only evaluate the relationship between economic growth and infrastructure. Since this kind of analysis is evaluated from the supply side; i.e., it is assumed that demand is constant during the of investment, the indirect impact as a result of demand change can not be captured in a regression framework. General equilibrium analysis achieves a comprehensive outlook of the effect of infrastructure project on the economy from both the demand and the supply side.

Computable General Equilibrium (CGE) models are based on linear or nonlinear programming problems which maximize producer profits and consumer utilities, and at the same time satisfy a set of market clearing conditions that enables no excessive supplies of goods and services in an economy (Rutherford, 2008). Because of this nature of method, CGE models capture the interactions in the economy through many simultaneous equations with many variables from utility and profit maximization functions to foreign trade or labor market functions. And this macro and micro economic consistent mechanism based on a comprehensive data sources, so-called social accounting matrix (SAM), which captures from production and consumption interactions to public side and exterior relations of an economy.

The rest of this chapter is organized to discuss various CGE frameworks. First section summarizes national CGE models and second section discusses multi-regional CGE models which specifically focus on the impact assessment of transportation infrastructure.

1.2.1. Single region CGE models

CGE literature also starts with single-region national models just like in the input-output models. These models have been widely adopted for different kind of policy assessments for many countries including Turkey. These single region models are generally takes a country into account as a whole and evaluate impact of policies on national level.

Most single region models were originated from the famous publication of Dervis, De-Melo and Robinson (1982) Which is called “General Equilibrium Models for Development Policy”. This book is known as the source of CGE “folklore”. Many models were originated from this tradition.

ORANI is one of the early single region general equilibrium model which is developed for Australia (Dixon et al. 1982). It has been applied many times in analyses of the effects of comparative static analysis and forecasting (Horridge, 1986). According to Dixon (1986), the strength of general equilibrium models comes from their ability to handle inter-industry linkages. For example, in Dixon (1986), slow growth of foreign demand for Australian agriculture sector can improve the demand for mining sector by leading to a deterioration in real exchange rate.

Although the single region CGE models has been widely used, it is not possible to see impacts of policy assessments in geographical level. These models have limited power to evaluate regional spillovers since it has single-region modeling structure. Consequently, the analysis has to take place at the regional level to assess more accurate results (Banister and Berechman, 2001).

1.2.2. Multi-regional CGE models

Multi-regional CGE models which is also known as Spatial CGE are capable to measure distinct regional impacts and associated regional spillover effects caused by a policy shock, since prices and quantities in regional level are determined endogenously (Chen and Haynes, 2015).

CGE models in multi-regional level tend to cover more completely interregional linkages. These linkages can be both in the form of interregional flows of goods and in the form of factors such as migration or capital flows. And multi-regional models at this framework shed light to the regional effects of international, national or regional policies and events. So, regional scope can be composed according to needs and scope of the study. There exist some models that simply contains core region and rest of the world or rest of the country region. Lofgren and Robinson (1999) builds such a model for Tanzania in this fashion. One border region which is near to port and aggregated inland agricultural regions are in the focus of this study. Park and Hewings (2007) studies the impact of aging population in a CGE model also composed of two regions in which Chicago and rest of the US is interlinked with each other by migration, trade, and the social security system. However, one small region and one broad-region context in multi-regional studies can miss important interregional or national feedbacks, since the selected region is usually too small to affect the national or international aggregates (Lofgren and Robinson, 2002).

Alternatively, more disaggregated regional composition is more common at the current multi-regional CGE modeling. A number of multiregional CGE models appears dating back to 1990s in the literature. And even if these studies vary greatly from each other in terms of approach and purposes, all of these studies follow common features of CGE folklore. According to Partridge and Rickman (2010), regional CGE models can be extended by embedding new theory directly into the existing regional CGE framework for particular regional policy analysis which will serve to a specific need. TERM (Dixon et al., 2012) and B-MARIA models (Haddad and Hewings, 1998) are one of the most well known models which has extended to specific research questions for many times which we will mention later on this section.

Alternative to extended version of available CGE models, linked sub-modules are also very common at the multi regional CGE modeling literature. These sub modules can be used on the input side or on the output side of the regional CGE model. CGE models which is linked to sub modules in the input side uses the output of a sub model such as a transport model which provide input to a CGE model on freight, commuting and shopping costs. This context is also the method we will follow in this thesis. Another one would be a regional CGE model which is linked to sub modules in the output side of the model uses outputs from a multiregional CGE model as an inputs to a detailed sub model. All of these linked models run iteratively and feeding each other accordingly.

On the other hand, CGE analysis related with transportation issues are usually constructed in a multi-regional structure linked with a transport network. Here, transportation network module works as a linked sub model which will feed the CGE model. Consequently, models which provides the link between CGE models and transportation network are directly spatial CGE models and one of the early studies in this area would be Buckley (1992) for USA and Roson (1994) for Sweden and then Bröcker (1998) for European Union, Haddad and Hewings (1999) for Brazil, Kim and Hewings (2009) for South Korea and Ivanova (2003) for Norway.

Transport margins enter to scene and treated as part of the trade in all of these CGE models. But the key difference is the representation of transport costs in the model. *CGEurope* Bröcker (1998) models transport costs with an explicit representation in the form of transport agent and it includes it to the price of final goods and services, like in Haddad and Hewings (1999), Kim and Hewings (2009) and Ivanova (2003). On the contrary, Buckley (1992) studies the impacts of transportation systems on the spatial economy, but it ignores the representation of transportation systems in a network framework

If we need to give some insight into details and output of the related models, in particular, Kim and Hewings (2009) explores the impacts of new highway projects in South Korea on welfare and industrial value added in a multi-regional CGE linked with a transportation network model. According to this model, 9 different road projects in East-West corridor increases the GDP by 0.3% over the 30 period time horizon with 0.016% of the GDP as the network effect.

B-MARIA model developed by Hewings and Haddad (2001) is another fully operational first multi-regional CGE model which focus on the transportation issues in Brazil. *B-MARIA* model divides the country to 3 sub regions and identifies 40 sectors in each region. According to this model, 20 % improvement in total factor productivity in the Center-South region has a direct impact on Gross Regional Product of approximately 0.76%. And also 21.77% increase in total factor productivity for North and 25.88% increase for Northeast region are needed to get a similar effect in related regions' output.

B-MARIA-PORT model which focus on the productivity and efficiency of ports in Brazil also investigates the effects of port productivity differentials on regional growth (Haddad et al., 2010). According to this model, transportation investments in south has negative impacts on northern regions by averting the trade potential from poorer northern regions to south. Also Haddad and Hewings (2005) assessed economic effects of changes in Brazilian road transportation policy by applying a multiregional CGE model. They indtroduce an approach which includes non-constant returns and non-iceberg transportation cost assumptions and results indicates an asymmetric impacts of transportation investment on regional trade which diverts the trade from poorer regions in Brazil.

CGEurope is another very important Spatial CGE model developed by Bröcker (1998). This model is also used especially for spatial analysis on the distribution of welfare effects caused by changes accessibility levels within and between regions (Bröcker *et al.*, 2001). Bröcker (2000) describes how the model can be applied to the assessment of spatial economic effects of transport. *CGEurope* model contains NUTS-2 level 1373 regions including Russia and Turkey as a single region. This model uses the European Transport Network *TEN-T* model to see spatial effects of transportation investments.

The key feature of *CGEurope* model is the represantion of transportation costs in the model. It is based on the *iceberg* assumption. The *iceberg* transportation cost assumption based on the fact that a portion of the commodity transported dissipates itself during the transportation process (Bröcker, 1998). Hence, smaller amount of commodity transported arrives to destination since some part of the commodity would have been 'used' in the form of transportation costs. It brings an easy way which needs less data, since it avoids the need for constructing a sector offering transportation services.

The Bröcker methodology has also been applied in *PINGO* model which is builded for Norway (Ivanova et al, 2003). Ivanova et al. (2003) develop a Spatial CGE model (*PINGO* model) that can be used to assess the regional economic impacts of new routes in Norwegian transport network. *PINGO* model is a static Spatial CGE model used to forecast regional and interregional freight transport in Norway (Vold and Hansen, 2007). *PINGO* model which has 19 regions and 10 sectors also handle the trade flows between regions in Norway and it is also linked to a network model. This model has been applied to evaluate the pricing strategy for interurban road transport.

Almeida et al. (2008) uses the same model based on Bröcker's iceberg approach. The main finding of this study indicates that the promotion of regional equity is insignificant if the transport infrastructure improvements is focused only among poor regions in Brazil. In the vice versa case, there is an increase in regional income inequalities, If the transport infrastructure improvement links are concentrated only among rich regions. On contrary, if the improvements are targeted to the roads lining poor regions and rich ones, there is greater promotion of regional equity.

First step towards to Turkish Spatial CGE model will be to build the data source of the model which is known as the Multi-Regional Social Accounting Matrix.

2. MULTI-REGIONAL SOCIAL ACCOUNTING MATRIX FOR TURKEY[1]

Computable General Equilibrium (CGE) models require comprehensive data to produce quantitative results. A Social Accounting Matrix (SAM) provides the underlying data framework for this type of models and analysis. A SAM includes both input-output and national income and product accounts in a consistent framework. This part of thesis provides a Multi-Regional Social Accounting Matrix for Turkey in a convenient format, which will enable modelers to construct Spatial or Multi-Regional CGE models. The format we explained here can be used to construct also for developing or underdeveloped countries which suffer from different kind of regional data.

The availability of regional employment data, interregional trade flows data and lastly TurkStat's various kind of regional data are permitting us to extend national level Social Accounting Matrix (SAM) to Multi-Regional SAM. Consequently, this framework will enable us to analyze the impact of regional policies, i.e., from new infrastructure investments like airport and highway projects to the impact of unexpected events like earthquakes.

Yeldan *et al.* (2012) try to examine Turkey via two large regions, i.e., west Anatolia and east Anatolia regions, and two sector Input-Output table and Social Accounting Matrix from national accounts. To best of our knowledge, a multi-regional SAM (MRSAM) for Turkey does not exist which has higher than two regions in geographic scope. So, the goal of this paper is to describe the steps to build a MRSAM constituting of 11 regions in Turkey. One can also disaggregate or aggregate regional decomposition according to needs. This section discusses the different data sources used and how the data were organized to build a MRSAM.

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In the following parts, respectively, building process of national SAM will be described. Here, the true definition of government block in national SAM has a vital importance such a country like Turkey, whose public sector has a high share in the economy. A proper way, which is described at Telli *et al.* (2007) has been adopted to build national Turkish SAM. And lastly, regionalization process of national SAM, namely building the multiregional SAM will be discussed. Here is the demonstration of interregional trade in MRSAM and their estimation brings a very convenient and appropriate way to regionalize the Social Accounting Matrix. The trade flows between different regions, which is necessary to compile multi-regional SAM has been estimated in accordance to a modified version of CHARM method (Tobben and Kronenberg, 2015).

2. 1. System of National Social Accounting Matrix

Nobel Prize winning economist Richard Stone established the basic framework for the standardized System of National Economic Accounts (Miller and Blair, 2009). According to Stone (1961), these System of National Accounts (SNA) worked as a bridge between statistics and applied economic analysis before the general equilibrium models were invented.

Conceptually, SNA framework takes us back to the notion of circular flow of economic resources in an economy. Because SNA includes not only economic production which display commodity flows between industries but also the flow of income associated with production. In the simplest way, there are firms that produce goods and services and household that purchase those goods and services in an economy. Household also works for the firms and receives income from them. At the end of the day, the whole income generated in the economy is exactly equal to expenditure in the economy. This is known as the fundamental tenet of the circular flow in an economy.

When SNA is combined with input-output accounts, which incorporate the inter-industry linkages and also final demand in the economy, it represents the economy in a more comprehensive way (Miller and Blair, 2009). This combination today is known as Social Accounting Matrix (SAM) which shows us a more comprehensive and disaggregated snapshot of the economy during a given year. SAM framework includes more detailed information about the roles of labor, household, firms, government and the other institutions or agents in the economy. Table 1 below presents a schematic SAM.

	Activities	Commodit.	Labor	Capital	HH	Firms	SSI	Govern.	D.Banks	Prv.Inv.	Pub.In.	ROW	Total
Activities		Domestic Production											
Commodities	Intermediate Use				HH Cons.			Public Consump.		Invest. Demand	Pub.Inv Demand	Export	
Labor	Labor Input												
Capital	Capital Input												
HH			Labor Income			Profit	Social Trans.	Social Transfer	Distrib. Profit			Remitten.	
Firms				Capital Income				Subsidies				FDI	
SSI			SSI Premium					Transfer for Deficits					
Govern.	Taxes on Production	Taxes on Products			Direct Tax	Factor Inc + Tax							
D.Banks					HH Saving			Interest Payment				Foreign Sources	
Private Inv.									Priv. Inv.				
Public Inv.								Public Saving	Finance. to Inv.				
ROW		Import				Transf.		Interest Payments	Interest Payment				
Total													

Figure 2.1: Schematic National Social Accounting Matrix.

As can be seen at the Figure 2.1, SAM is a square matrix in which account has its own row and column. Expenditures or payments are listed in columns and the receipts or incomes are in rows. The row sum of a given account must equal the column sum of the same account. So it means all expenditures must equal the receipt or income of corresponding account.

One of the most important difference at the formulation of a SAM is the distinction between production activities and commodities. Production activities produce different goods and services by buying raw or intermediate goods and services from commodity account. Also activity accounts pay production taxes to the government and the remain portion, value added, distributed to labor and capital. Sum of the sectoral value added and intermediate use gives us total domestic production by sectors, i.e., row total of domestic output which commodity accounts get it from production accounts. Commodity account will pay product taxes to government. And also, commodity account will demand goods and services produced in foreign countries. They will pay to import sector for this transaction.

SAM framework also distinguishes the role of household. At least one household account is necessary for a SAM but it can also be disaggregated according to education or income level etc. Here, household account is not only final demander in an economy but also as a provider of labor, i.e., value added factor production. So, this expansion results in an additional row and column which labeled Households. This account will get a factor income (labor compensation less social security premiums) from labor account, as well as profit from firms, pensions from Social Security Institute (SSI), social transfers from government, interest income from domestic banking sector and remittances from the family members in abroad. Household will spend this income to different sectors in commodity account, pay direct taxes to government and save the rest amount.

Firms earn capital income from capital account and get subsidies and transfers from government and transfers from rest of the world. This income is distributed to households as a profit and some part of it goes to government as direct taxes and as well as public firms' profit as a factor income.

We need to emphasize something here about government account. The government here is distinct from administrative public activities which are included in the production activities' account. These public activities are included in the service subsector of activity accounts. The government account here allocates its current expenditures on buying goods and services from commodity sectors and as well as transfers to household, subsidies to firms, transfers to SSI and interest payments to domestic banking and also rest of the world. The remaining of the government income is the saving which goes to public investment. On the other hand, government collects the production and product taxes (which also includes tariffs) from activity and commodity accounts, direct taxes and factor income from households and firms. Government account closes when raw and column sum equals each other. By following Telli *et al.* (2007), we also added social security institution to Turkish SAM. This account will channel social security funds into government and to households as a mere intermediary.

Domestic Banks account, just like in SSI account, here functions as an intermediary and channels flow of funds among institutions. In our settings, Domestic Bank account gets the household savings and government interest payments as an income and allocates the resources to private investment, to public investment for the deficit part of the public budget and also pays to household as a distributed profit and interest of foreign debt. All of these flows reflect the fashion in investment-saving relation in Walrasian economy. Investment accounts spend available funds to investment goods. And lastly, Rest of the World (ROW) account describes the relations with exterior world.

At the end of the day, Multi-Regional SAM needs so many data from different sources. The first procedure here is to build a national SAM and then disaggregate the national SAM using the published regional data, which will be explained in the following part. The structure of the national SAM is already shown in Figure 2.1.

2.2. Data Needs of Turkish National SAM

To build a national SAM which has these different networks of the same economy explained above, one needs to unify closely related balances of the economy and collect the related data. These accounting types can be classified into three main frameworks. First main part is input-output tables. These tables exhibit inter-sectoral flow of goods and services in the economy. Secondly, Public Sector Borrowing Requirement which is also known as national balance sheet show real and nominal assets and their distributions in the economy. And lastly, Balance of Payments shed light to the flows with exterior world. SAM unifies these three main part and generate a more general picture of the economy.

These three main framework will categorize the procedure of compiling a national SAM for Turkey. Datasets needed to compile the SAM are shown in the Table 2.1 below.

Table 2.1: Data Sources of Relevant Accounts.

Commodity and Activity Accounts	2012 Supply and Use Tables in basic prices (TurkStat, 2016) 2015 GDP by kind of economic activity, income approach (TurkStat, 2016) 2015 Institutional Sector Accounts (TurkStat, 2016)
Factor Accounts	2012 Input Output Table (TurkStat, 2016) 2015 GDP by kind of economic activity, inc. approach table (TurkStat, 2016) 2015 Work Place and Insured Person Statistics (Social Security Inst., 2015)
Institutions	2012 Input Output Table (TurkStat, 2016) 2015 GDP by expenditure approach table (TurkStat, 2016) 2015 Institutional Sector Accounts (TurkStat, 2016)
Public Accounts	2015 Public Sector Borrowing Requirements Table (Ministry of Development, 2017)
Social Securty Account	2015 Work Place and Insured Person Statistics (SSI, 2015)
Foreign Balance	2015 Balance of Payments 6th Handbook (Central Bank of Turkey, 2017)
Foreign Trade Accounts	Commodity Composition of Export Table (TurkStat, 2016) Imports by ISIC Rev. 3 Table (TurkStat, 2017)

The commodity and activity accounts in the national SAM are derived from aggregations of the commodity and activity accounts in the national SAM. In our framework, Turkish MRSAM has 8 broad aggregated-commodities and activities. These are agriculture, food processing, textile, machinery, construction, transportation, other industries and lastly service sector. The institutions in our context consist of household, enterprises, government, domestic banking and social security institution. Now, we can start to define the building process of three main blocks of national SAM.

2.2.1. Balance of supply and demand / income and expenditure side

The first key table of SAM accounts is the so-called "USE" table, which provides information on the use of commodities by industries and final demand agents in the economy. Column of this table indicates demand of intermediate goods and rows indicate the use of these commodities by industries.

The second key table of SAM is the MAKE table. The transpose of this table refers to supply matrix in practice. Since industries use commodities to make commodities. Columns of MAKE table which is the expenditure side corresponds to a commodity and rows which income side correspond the production of that commodity.

The final demand side of our SAM will be based on also use and make tables. And also income of our agents in the model which include wages and salaries paid to labor, profits to capital and taxes to government is also heavily based on these table. Consequently, one of the main part of SAM, i.e., demand and supply parts, will be based on 2012 Input-Output Tables (TurkStat, 2016a). Input-Output (IO) table will serve us to calculate intermediate demand shares, value added shares, tax shares and final demand shares for some economic agents in the economy. So, IO table is the key table to build a SAM for the year 2015, which will be base year our SAM.

To calculate the intermediate good consumption by industry, one needs to calculate technical coefficients (a_j) of related industry. These coefficents basicly related with the shares of intermediate goods (z_j) and value added components of total output (x_j) at the related industry. And the technical coefficient can be computed by the following way:

$$a_j = \frac{z_j}{x_j} \tag{1}$$

These coefficients then will be used to find intermediate consumption and value added by industry for the year 2015. And total intermediate consumption of the economy in 2015 is 2.059 billion TL according to Institutional Sector Accounts (TurkStat, 2016f). Value added and taxes less subsidy by kind of economic activity (NACE Rev. 2) data (TurkStat, 2016c) is used to calculate 2015 values of related accounts. In our national SAM, manufacturing sector is disaggregated by using 2012 IO shares to find textile, food processing and machinery industry.

2.2.2. Balance of public sector side

After we calculate the government expenditures and investments by sectors, Public Sector General Equilibrium (PSGE) table, currently prepared by Ministry of Development, will constitute the basis of the remaining public side of the SAM. PSGE table defines public sector revenues and disposable income and also addresses of this income, which is used for government consumption, investment and transfers to household and firms. Table 2.2 below presents the aggregated version of Turkish PSGE, which is generated by Ministry of Development on annual basis.

Table 2.2: Public Sector General Equilibrium for 2015 (in millions TL).

1. REVENUES	514.6
A.Tax Revenue	
Direct + Indirect	403.1
B. Non Tax revenues	42.4
C. Factor Income	69.1
2. EXPENDITURES	
A. Social Funds	-16.3
B.Transfers	-176.4
Public disposable income	321.9
(1-2A-2B)	
C. Current Expenditures	-236.1
public saving (1-2A-2B-2C)	85.9
D. Public Investment	-95.4
Saving/investment Balance	-9.5
E. Capital Transfers	11.01
F. Stock Changes	-0.672
Public Sector Borrowing Requirement	-0.8

This table enables a proper way to build real size of the public sector over the economy. The key variable here is public saving. As seen, one can calculate that subtracting social funds, transfers and current expenditures from governments total revenues. In 2015, public saving is 85.890 billion TL. This value is equal to public investment which is directly financed by government itself. The difference between public investment and public saving gives us the Public Saving-Investment Balance. There exists a deficit in this balance (9.533 billion TL for 2015). In 2003, this deficit has been reached to its peak, 35.553 billion TL and it decreased substantially with a better administration in public finance sector. Public Saving-Investment deficit will be financed by Domestic Banking account in the SAM framework.

Social Funds in PSGE table shows the net income of social security institutions, which namely is proper revenues from social security incomes collected, over the social security expenditures incurred by those institutions. The deficit of Social Security Institution is 16.276 billion TL in 2015. This amount will be transferred by government to equilibrate the income and expenditures of SSI account in the SAM. Social security premium payments and SSI pension payments and health benefits are taken from Work Place and Insured Person Statistics (SSI, 2015). Labor account will give social security taxes to SSI; and SSI will allocate the social benefits to household in the SAM framework.

Current transfers in PSGE table will be allocated among households, enterprises, domestic banks and rest of the world. Firms will get transfer income in the form of production subsidies from government. Subsidies data by different sectors are available at GDP by kind of economic activity tables, which is calculated by income approach (TurkStat, 2016). Also Domestic Banking account receives interest income from government. Rest of the world account receives interest income from public sector. Balance of payments accounting for the interest cost of public sector is the main source that we will already describe in details at the next section. Household transfers in this setting gets simply a residual from total current transfers.

On the other hand, government revenues in the SAM framework constitute of revenues those levied on production, enterprises and households. Productive sectors incur taxes on production or activities whereas commodity account pays taxes on products, which include sales taxes and import tariffs to government account in SAM. Taxes on production and taxes on products (in total) data are taken from Institutional Sector

Accounts (TurkStat, 2016c). These total tax values are disaggregated according to information in 2012 Input Output Table and GDP by kind of economic activity, income approach table (TurkStat, 2016c). The important point here needed emphasizing is that taxes on production is not calculated taxes less subsidies. Subsidies will assign separately in Government Transfers to Enterprises account.

Enterprises pay gross factor income and corporate taxes to government account. Total public sector factor income for 2015 is 69.103.877 TL. In SAM, government account will acquire factor income from enterprise sector. However, PSGE table does not contain some tax breakdowns, such as corporate taxes. Direct Tax definition in PSGE table contains both income and corporate taxes without any explicit relevant line items. One needs to disaggregate these two.

2.2.3. Foreign balance side

Rest of the World (ROW) account constitutes the balance with exterior world. Two important parts of this account are export and import accounts. Totals of these two accounts are taken from Balance of Payments (Central Bank of the Republic of Turkey, 2017). Their breakdowns by sectors (ISIC rev 3) are available (Turkstat, 2016b).

Payments to rest of the world contain import and institutional payments. Enterprises pay interest for foreign resources held, make profit transfers to abroad and government pays foreign interest also. Debt service data utilized here comes also from Balance of Payments (Central Bank of the Republic of Turkey, 2017). One needs to calculate interest payments and icomes for both private sector and public sector separately from sub accounts of Balance of Payments, i.e., primary income and financial account of BoP. Private sector interest payments is the sum of short term and long term interest payments by banks, Central Bank of the Republic of Turkey and other sectors. This data also comes from Loans subsector of BoP. Firms' profits transfer to abroad data corresponds to direct investment "debit" in primary income sub-account of BoP.

On the other hand, household receives remittances and enterprises get entrepreneur income and interest income from abroad. Unrequited transfers and workers' remittances data are also taken from Balance of Payments. And lastly, firms' foreign currency income is based on a residual of exterior sources after all institutions earn incomes and incur foreign exchange expenses. Table 2.3 shows our calculation of income and spending side of ROW account.

Table 2.3: Balance of ROW account (in millions TL).

ROW Income	560.3
Export	545.4
Remittances	2.6
Firms foreign currency income	11.1
Unrequited Transfers	1.3
ROW Payments	643.2
Import	606.8
Private Sector Interest Payments	25.1
Firms' Profit Transfers	9.7
Public Sector Interest Payments	1.6
Foreign Savings	82.9
Net Factor Income	-22.8
Unrequited Transfers	1.3

So far, all accounts are closed step by step according to an order. The last thing is to calculate savings in the economy. The breakdowns of balance of ROW account table above is also very important to find Gross National Income (GNI), which will be used as a satellite account.

GNI shows the total domestic and foreign output claimed by residents of a country. So, it is extended version of GDP and this extension includes the Unrequited Transfers and Net Factor Income from Abroad. It can be identified like the following formula:

$$NI = C + I + (X - M) + NFI + UT \qquad (2)$$

And if we make an arrangement like below,

$$GNI + (M - X - NFI - UT) = C + I \qquad (3)$$

Equation 3 gives the sources of the national consumption and investment, which also represents the domestic absorption. Left hand side of the equation shows respectively domestic sources and foreign sources. Part in brackets on left hand side, foreign sources, is exactly equal to the volume of Current Account balance in the Balance of Payments.

At the classic GDP framework, total foreign resource is only equal to foreign trade deficit, i.e., $X - M$. However, when we extend the definition of national income from GDP to GNI, total foreign savings or resources will be equal to Current Account deficit rather then trade deficit. One needs to use GNI definition to calculate an accurate private disposable income and private savings. We already know that saving is the linear distance between income and the amount of income that is consumed ($S = Y - C$).

Since both government and household saves in the economy, total saving constitutes of public saving (S_g) and prviate saving (S_{hh}). One can calculate the household saving by substracting public saving from total saving which is calculated like above.

Last step of the procedure of building national SAM is to equalize the row and column sum of the national SAM. As seen above, constructing a SAM necessitates so many datasets from a variety of sources, which is also including data from prior years. These differences cause one to get unbalanced row and column sums in national SAM. There exists various kind of methods to solve this problem in the literature.

2.3. Regionalization

Regional information from the regional SAMs is retained for the commodity, activity, factor (labor and capital), enterprise and regional household. The accounts for government, social security, and investment accounts present national level information. Each regional SAM contains one regional household, enterprise, labor and capital accounts. Government, Investment and SSI is in the country level and they interact with each of our regions in our multi regional SAM. The interregional trade flows depict between which two regions the trade is taking place.

The geographic decomposition of the Multi-Regional SAM will constitute of 11 regions. Regional statistical system of TurkStat follows European Union Nomenclature of Territorial Units for Statistics (NUTS) system. Regional decomposition constitutes of aggregation of NUTS 1 regions except biggest three cities; Istanbul, Ankara and Izmir. Regional decomposition of our Multi-Regional SAM can be seen at Appendix A.

In order to generate Multi-Regional SAM, one needs to use various data from different sources. However, existing data sets are not sufficient to construct the MRSAM based on a fully survey data. According to Hewings (1985), one way to do this is to conduct a survey, which covers sufficiently large sample of the regional industries. This common problem in this field gives rise to numerous non-survey methods to generate regional IO tables based on combinations of regional indicators and national datasets. So, the first procedure was to build a national SAM, which is explained in the previous part, and then disaggregate the national SAM using the published regional data.

In the literature, there are many examples of regionalization of national tables for single or multiple regions. The regionalization can be performed by different nonsurvey methods such as Location Quations (LQ), RAS, Cross Entropy (CE), Supply-Demand Pool or Commodity Balance (CB) etc.

Even the family of Location Quations (LQ) methods has many members. Simple Location Quotion (SLQ) is one the most used in many regional studies. The other member of this family are Cross-Industry Quotient (CIQ), developed by Schaffer and Cu (1969); Purchase-Only Location Quotient (PLQ), developed by Consad Research Corporation (1967); the semilogarithmic Quotient and its variants FLQ and AFLQ, developed by respectively Round (1972) and Flegg *et al.* (1995).

Lahr (1993) argues that only the LQ and CB methods should be regarded as "true" nonsurvey method. These two methods will be explained shortly. Then, we will continue from the method, Commodity Balance, we used in this study.

LQ methods are based on the assumption that each regional input-output coefficient $a_{i,j}^r$ is related to its national counterpart $a_{i,j}^n$ in the following way:

$$a_{i,j}^r = t_{i,j}.\, a_{i,j}^n \tag{4}$$

The term $t_{i,j}$ here is the regional purchase coefficient and its value exactly depends on the location quation. Mathematically, LQ_i can be defined as

$$LQ_i^r = \frac{x_i^r / x^r}{x_i^n / x^n} \tag{5}$$

The numerator indicates the proportion of region r's total output that is contributed by sector i. On the other hand, the denominator represents the proportion of total national output that is contributed by sector i in national level. Namely, this method tells us the sector i's representation in the relevant region. If the LQ_i is smaller than one, $t_{i,j}$ is equal the LQ_i^r. If the location quation for the relevant industry is grater than or equal to one, it means that region is self sufficient in the relevant sector and $t_{i,j}$ is equal to one and consequently $a_{i,j}^r = a_{i,j}^n$.

In this fashion, self sufficient sector in the region has the national technical coefficient but the other regional sector which has smaller capacity is being to punished by lower technical coefficient which equals the LQ_i^r.

An alternative nonsurvey method is Supply-Demand Pool or Commodity Balance approach, based on the work by Isard (1953). The regional commodity balance is the difference between regional output and the sum of intermediate demand, final demand and net export of region. Commodity balance can be stated as the following formula:

$$CB_i^r = (x_i^r + m_i^r) - (z_i^r + fd_i^r + e_i^r) \quad (6)$$

First thing first, to compute regional CBs, one needs to find regional output of each sector and total regional intermediate demand. National intermediate demand data is available at Institutional Sector Accounts (TurkStat, 2015). Regional breakdowns of intermediate demand of sectors will be estimated from regional employment data (SSI, 2015), assuming that labor productivity in different regions of Turkey are equal to national average. In recent years, Social Security Institution in Turkey has undergone major changes and three different segments of the institution (Bagkur, SSK and Emekli Sandigi) have merged. Informal employment also decreases day by day. The scope of the employment dataset still covers these three segments of SSI, i.e., labor force in public sector (Emekli Sandigi or 4/1c), voluntarily insured people (Bagkur or 4/1b) and compulsory insured people (SSK or 4/1a). Compulsory insured people dataset is the vital part of employment datasets. It covers employment data in NACE sectoral level for each city. We added the public employment to service sector in each city. And lastly, voluntarily insured people data (Bagkur) covers two sectors, agriculture and others. We allocated voluntarily insured people in the "other" sector to the sectors in our MRSAM after we added agricultural employment of voluntarily employed people to agriculture sector. After these corrections, we can start to build our MRSAM.

	Industry	Commodity	Factor	Institution	Industry	Commodity	Factor	Institution	Industry	Commodity	Factor	Institution	Total
Industry													
Commodity													
Factor													
Institution													
Industry													
Commodity													
Factor													
Institution													
Industry													
Commodity													
Factor													
Institution													
Total													

Figure 2.2: Demonstration of Multi-Regional Social Accounting Matrix.

Diagonal parts of the generic MRSAM demonstrated at Figure 2.2 above are different regions. Each grey shaded area at the Figure 2.2 represents the regional commodity and income balances. Dark grey shaded areas demonstrate the trade between regions. As seen, the form of interregional commodity flow between regions are from commodity to commodity account. One of the biggest advantage of this demonstration in MRSAM setting is to avoid from complex trade relation between economic agents in the economy, i.e., industries intermediate demand from other regions or regional households' demand from other regions' commodity market etc. In this way, we assume that regional commodity demand/supply from/to other regions will be met by the commodity pools. At the end of the day, this form will enable commodity balance in the regions.

Generation of regional input-output tables consists of a sequence of steps based on national Social Accounting Matrix, which is explained in previous part, and regional account datasets. The main approach here is to incorporate superior information in the most efficient way like in the following steps of generation of our MRSAM.

2.3.1. Production block

Regional intermediate demand can be estimated by:

$$z_i^r = \frac{L_i^r}{L_i^n} z_i^n \tag{7}$$

So, the weight of regional employment in sector i over national employment level at the relevant sector will be used to calculate regional intermediate demand of i (z_i^r). Here, z_i^n denotes the national intermediate demand of the same commodity, which already introduced in the national SAM.

After we get the regional total intermediate demand by sectors, it is easier to calculate used inputs or intermediate demand matrix (Z). We assume that regional and national input requirements are identical, namely there is no difference between regions in term of input needed to produce one unit of output. So, the input requirements of regional sectors can be calculated like the following formula:

$$z_{i,j}^r = a_{i,j} z_i^r \tag{8}$$

Technical coefficient here, $a_{i,j}$, is defined as the amount of input i that the economy uses to produce one unit of output i. and the technical coefficient can be computed by the following way:

$$a_{i,j} = \frac{z_{i,j}}{z_i} \tag{9}$$

Equation yields an estimate of interindustry transaction matrix (Z^r) for each region. Once this is known, total regional output by sector is just the total of column sum of regional intermediate demand and primary factor demand.

Primary factor demand for each region, i.e., labor and capital, will be calculated via our satellite accounts. It is the regional GDP datasets. Regional GDP datasets (TurkStat, 2016i) will serve as an anchor to calculate a better regional labor and capital values for relevant sectors in regions. From the income side, Regional GDP will be the sum of "compensation of employments" which will go to labor as income, "operating surplus" which will go to firms as profit and "net taxes on production". This dataset is available in sectoral details for each city (TurkStat, 2016g and 2016i). However, sectoral details include only the main sectors in the economy, i.e., industry, agriculture and service sectors. One needs to do necessary calculations to disaggregate sectoral decomposition. Here, we used again employment data as a location quation to disaggregate the sectors in region.

2.3.2. Final demand side

These sub-tables may be broadly classified into MRSAM core accounts and satellite (auxiliary) accounts. The core accounts, i.e, intermediate demand, domestic production, final demand accounts by region and economic branch etc., are those which appear in the final MRSAM. These accounts explained in the previous part.

The most important regional satellite account which will serve as a control-totals for the core accounts, is Regional Gross Domestic Product. This satellite account does not appear in the final MRSAM, but it is the sum of the regional investment, regional consumption and regional net export (both foreign and domestic). Regional GDP data is available at even city level (Turkstat, 2016g). Regional GDP will also include the interregional trade in the economy as in following formula.

$$GDP_i^r = HHC_i^r + GovC_i^r + PrivInv_i^r + PubInv_i^r + (Ex_i^r - M_i^r) + (DomEx_i^r - DomM_i^r) \tag{10}$$

Household consumption data is available in regional level. However, sectoral classification does not fit to sectoral decomposition of IOTs. Since people more or less consume same kind of goods, the total value of regional household consumption is more important than sub division of this consumption in regional level. So, regional total household consumption (1.44 billion TL in 2015) can be calculated as the following fashion:

$$HHC^r = {DI^r}/{DI^N} \, .HHC^N \tag{11}$$

We assumed that fixed share of income consumed in all regions and then, national shares in household consumption account used to calculate breakdowns of regional household consumption by sectors. Regional disposable household income (DI^r) dataset and regional population in household level are available (TurkStat, 2016h).

On the public side of final demand, public expenditures and public revenue datasets for the local and central government at the city level are available (Ministry of Development, 2016). Scope of the public expenditure datasets contains also interest payments and capital formation. One needs to adjust these tables to reach more accurate city level public expenditure totals. If interest payments and capital formation are neted out from the total public expenditure for each city, we get the total public expenditure levels for each city. In addition, these totals will be defined as the portion of national public expenditure by sectors in each region of MRSAM. It can be seen at Table 6, regional percentages of total 324 Billion TL government expenditures in 2015.

Table 2.4: Regional Public Investment Shares (Ministry of Development, 2016).

Istanbul	17 %
Marmara	12.60 %
Izmir	5 %
Aegean	6.20 %
Ankara	13.60 %
Central Anatolia	7.50 %
iterranean	11.60 %

Table 2.4 (Continued): Regional Public Inv. Shares (Ministry of Dev., 2016).

Soth East	9 %
East Anatolia	7.80 %
West Black Sea	5.60 %
East Black Sea	3.70 %

Public investment data is another available data in regional level provided by Ministry of Development on annual basis. The scope of investment data provided by Ministry of Development are for each institutional breakdown of public service sector. One needs to disaggregate and calculate investment total according to the sector of related institutions. For the sake of consistency, we did some corrections which will equalize the sum of regional sectoral investments to national sectoral investment totals. Regional public investment of sectoral breakdowns can be seen at the following figure.

Regional private investment for each sector will be obtained being simply a residual from our regional GDP satellite account. One needs to set up regional household and government expenditure by sectoral breakdowns, regional public investment for each sector and regional foreign and domestic trade, i.e., export and import to ROW and other regions in Turkey. Then, regional private investment can easily be obtained from regional GDP equation. But before obtaining regional private investment, we need to know regional foreign trade data and interregional trade within the country.

Regional export and import datasets are available in regional level by three main sectors, i.e., agriculture, industry and service sectors (TurkStat, 2016b, 2017). Turkish Exporters' Assembly (TEA) publish sectoral export performance of cities tables in monthly and annual basis. One needs to use these datasets to get sectoral decomposition of TurkStat'regional export data in industry sector. Since there is a calculation difference between TEA and TurkStat, we prefer to use TEA sectoral breakdowns of export to disaggregate industry data in TurkStat. On the other hand, for the regional import account, there is no alternative data to decompose sectoral breakdowns. We here used the employment shares in regions to further disaggregate the import of industry sectors.

Lastly, interregional trade flows are the key part of MRSAM tables. Interregional trade flows are treated as an export and import from a region of origin to destination region in the framework of MRSAM. However, interregional trade flow data is not available in many countries. This is one of the reasons which make it harder to make analysis in multi-regional basis. However, one of the most important improvements in terms of regional data is the availability of interregional trade flows (Ministery of Science, Industry and Technology, 2016). Even if these data sets do not contain sectoral breakdowns, firstly, this valuable dataset will serve to obtain regional private investment by sectors which is calculated as a residual from regional GDP satellite account. And secondly, this dataset will guide us to calculate regional trade flows by sectors.

2.3.3. Interregional trade flows: off diagonal part of the multiregional SAM

The key feature of Multiregional Social Accounting Matrix is to enhance single region models in terms of geographical decomposition. The relation between different regions in economic terms occurs via the flows of goods and services between different regions in a country or a group of countries. So the off diagonal part of the MRSAM constitutes of trade and factor flows between economic agents in different regions.

Since data on the regional trade flows are only available as totals of interregional trade, a convenient method will be used in this study to compute regional trade flows between regions. In our context, two main sources will trigger the interregional trade. First one is Commodity Balance in the region (Isard, 1953) based on the principle of maximum local trade, i.e., "if commodity i is available from a local source, it will be purchased from that source" (Harrigan *et al.* 1981). Second one is the cross hauling which we will describe in details.

The first task is to calculate regional commodity balance of each sector in each region and regional commodity balance can calculate as in the following formula:

$$CB_i^r = (x_i^r + m_i^r) - (z_i^r + fd_i^r + e_i^r) \tag{12}$$

where x_i^r denotes total domestic production or output of sector i in region r and m_i^r denotes imports in region i, these two together indicate regional supply. Second part of the right hand side indicates the total demand in the region where z_i^r denotes regional total intermediate demand, fd_i^r and e_i^r denote final demand and export in the region respectively. At the end of the day, if commodity balance in a region has a negative value, i.e., regional output is insufficient to satisfy regional demand, then related region will satisfy their demand by importing good and services from other regions in country or vice versa. In Commodity Balance approach, regions are either importing to satisfy their regional demand in the related sector or exporting to other regions their supply surplus. Specific sector in the region is either export oriented or import oriented sector in this context. Another problem with this principle is that it ignores the fact that any industry commodity in practice will be an aggregation of a number of quite distinct commodities (Flegg *et al.* 2014). So, this method or other LQ methods alone will underestimate the interregional trade flows.

Many Turkish cities relative size in terms of economy are relatively smaller according to cities like Istanbul, Ankara or Izmir. A small region might have few local suppliers of each commodity, whereas more goods and services options might exist in a larger region. The key relative size here is the range of product in bigger regions. Even if small regions produce same kind of good, product differentiation allows to see more cross hauling between regions. One example can be given about food processing industry. For instance, majority of milk products of PINAR are produced in Izmir and shipped from Izmir, where company's headquarters is located, to Marmara region, where another important brand in milk products SUTAS has their production farms and headquarters in Karacabey/Bursa.

For these reasons, one might expect to see more cross-hauling between regions. Since commodity balance approach does not take cross hauling into account, size of the trade between regions will be underestimated. To overcome this problem, Kronenberg (2009) develops a nonsurvey method so-called CHARM that does account for cross-hauling. Cross-Hauling Adjusted Regionalization Method (CHARM) is basically a variant of the commodity balance (CB) approach and it is firstly applied for two region model. It accounts for cross-hauling by estimating product heterogeneity and calculates the interregional trade between two regions. Kronenberg (2009) assumes that Tobben and Kronenberg (2015) extends the CHARM method to the case bi and multi-regional IO tables.

The basic idea behind the CHARM approach is to calculate the shares of cross-hauling observed in national trade with the rest of the world and then apply these shares to regional data (Tobben and Kronenber, 2015). Mathematically, cross hauling is the difference between trade volume and trade balance, as seen in the following formula:

$$q_i = (e_i + m_i) - |e_i - m_i| \quad (13)$$

where $(e_i + m_i)$ is the volume (v_i) and $|e_i - m_i|$ is the balance of trade (b_i), respectively. Since cross hauling is a function product heterogeneity, we need to calculate the degree of product heterogeneity, h_i. For purposes of cross hauling estimation, q_i is proportional to the sum of domestic production, x_i^n, intermediate use, z_i^n, and domestic final use, fd_i^n, with the factor of heterogeneity of commodities, h_i, as represented in the following equation:

$$q_i^n = h_i^n(x_i^n + z_i^n + fd_i^n) \quad (14)$$

and it can be arranged like below:

$$h_i^n = \frac{q_i^n}{(x_i^n + z_i^n + fd_i^n)} = \frac{v_i^n - |b_i^n|}{(x_i^n + z_i^n + fd_i^n)} \quad (15)$$

The most important point in CHARM method (Kronenberg, 2009) is that regional and national cross-hauling shares are assumed to be equal for each commodity, $h_i^n = h_i^r$. The idea behind this argument suggests that national level product heterogeneity which is calculated from national export and import data and national level intermediate and final demand data, mirrors the regional level product heterogeneity also. Since this argument looks a bit problematic, it is basically based on the argument that product heterogeneity is a characteristic of commodities rather than of a specific region. So according to Kronenberg (2009), large share of cross-hauled commodities observed in national data indicates that the respective commodities are characterized by a high degree of heterogeneity.

On the other hand, product heterogeneity is the key part of cross hauling estimations and we believe that heterogeneity index calculated from national data may cause higher or lower trade flows in interregional trade of some specific sectors. On the contrary of the assumption about national product heterogeneity is equal to regional product heterogeneity in Kronenberg (2009), we modified the original CHARM method and calculated the product heterogeneity on the basis of regional data. The regional and national level product heterogeneities in Turkey can be seen at Table 7.

Table 2.5: Product Heterogeneity by Regions.

	Turkey	Istanbul	Marmara	Izmir	Aegean	Ankara	Central Anatolia	Mediter-ranean	South East	East Anatolia	West Black Sea	East Black Sea
Agr.	0.06691	0.13606	0.01141	0.05837	0.00945	0.01799	0.00965	0.04335	0.04102	0.00642	0.01352	0.00519
Food	0.05175	0.21415	0.03434	0.03285	0.02124	0.04910	0.00967	0.02051	0.02994	0.00149	0.00801	0.00097
Textile	0.11961	0.28886	0.08817	0.12134	0.07011	0.07463	0.06999	0.06996	0.05367	0.00858	0.02552	0.01014
Cons.	0	0	0	0	0	0	0	0	0	0	0	0
Trans.	0.05450	0.14611	0.05983	0.05328	0.03737	0.05746	0.02229	0.03470	0.03377	0.00341	0.02844	0.00442
Mach.	0.49117	0.56449	0.18610	0.27939	0.20754	0.36255	0.12216	0.11568	0.13617	0.04978	0.12337	0.07273
Othind	0.21688	0.41709	0.17219	0.20764	0.10705	0.19115	0.07715	0.12275	0.21570	0.02877	0.04551	0.07160
Serv.	0.01447	0.02226	0.00824	0.02103	0.00308	0.00126	0.00068	0.01188	0.00147	0.00084	0.00751	0.00016

Table above displays the values of h_i^nobtained using Turkish national data and h_i^r for each region using regional foreign trade, intermediate and final demand data like in equation (13). As can be seen, regional data can cause to vary product heterogeneity from region to region. Since this is the key variable to calculate cross hauling volume between regions, national level data can overestimate the flows for especially small economies like East Black Sea region or East Anatolia region.

By following CHARM method (Tobben and Kronenberg, 2015), regional domestic export to rest of Turkey and import from rest of Turkey values can be calculated from regional cross-hauling and commodity balance of regions. From cross-hauling eq. (13), gross exports and imports are calculated as the following way in Kronenberg (2009):

$$e_i = {(v_i + b_i)}/{2} \qquad m_i = {(v_i - b_i)}/{2} \tag{16}$$

From eq. (3), export or import can be written in terms of q_i, cross hauling, and it also equals trade volume and trade balance like above. However, Tobben and Kronenberg (2015) use regional commodity balance equation (Equation 2) in calculation in the interregional trade flows. By subtracting foreign imports and exports from regional commodity balance system, the remaining potential for cross-hauling in interregional trade for each region is taken into account in this fashion. We also use regional commodity balance rather than trade balance in the original CHARM method. Regional export to rest of Turkey and import from rest of Turkey for each region can be calculated like in the following ways:

$$e_i^r = \frac{q_i^r + |cb_i^r| + cb_i^r}{2} \tag{17}$$

$$m_i^r = \frac{q_i^r + |cb_i^r| - cb_i^r}{2} \tag{18}$$

Here, import and export are written as functions of trade volumes and trade balances for each commodity in each region. We need to emphasize once more that trade volume is equal to the sum of cross hauling and trade balance for each commodity in each region from equation (12).

All of these efforts can deliver estimates of interregional trade flows between region and the rest of the region as a whole. Namely, these export and import estimates do not constitute an origin destination matrix of interregional trade. It only delivers row and column sum of this matrix. So, the second step is to allocate these row and column sums to bilateral basis. Namely, we need to define the flows between Istanbul and Marmara, Ankara, Izmir etc. instead of the rest of Turkey. We know that sum of the regional imports from the rest of the country for each product equals the regional export to exports to rest of the country for each product. Our findings are very close to interregional trade data of Ministry of Science, Industry and Technology as can be seen at Table 8. One needs to note that, survey data also includes the transportation and trade margins and related taxes. However, our estimations do not take care these margins into account for the sake of price consistency in MRSAM.[2]

Table 2.6: Regional Domestic Trade (in Million TL).

	Export to ROT		Import from ROT	
	Survey Data	Estimation Results	Survey Data	Estimation Results
Istanbul	475.2	421.2	424.4	386.6
Marmara	220.7	164.1	179.1	103.2
Izmir	99.8	51.6	82.1	31.2
Aegean	51.4	39.2	68.1	52.1
Ankara	177.3	65.5	168.5	62.1
Central Ana.	53.5	37.9	73.9	54.6
Mediterranean	90.6	39.4	114.1	59.9
South East	51.8	35.6	74	68
East Anatolia	13.7	22.7	32.4	44.71
West Black Sea	38.3	26.8	45.7	33.19
East Black Sea	14.2	19.5	24.3	29.2

From related region to rest of Turkey, trade will constitute row and column sum of interregional trade matrix in origin-destination basis. To further disaggregation of these row and column sum of interregional trade matrix, we will fallow a simple approach here, instead of some gravity models or some mechanical and mathematical methods such as RAS. By following Tobben and Kronenberg (2015), the approach for generating initial values that we adopted is to allocate imports or exports from the rest of the country to the regions of origin according to their market share in total interregional imports or exports (except exports of the importing region or vice versa).

[2] if one uses survey data to disaggregate sectoral breakdowns, then further correction is needed to avoid double counting of taxes and margins.

Aggregated version of interregional trade flows (which is not including sectoral decomposition of trade) can be seen at Appendix A2. Interregional trade flows between regions can be estimated as:

$$t_i^{rs} = \frac{t_i^{roc\,s}}{\sum t_i - t_i^{s\,roc}} \tag{18}$$

Where t_i^{rs} denotes the export from region r to region s in sector i, $\sum t_i$ denotes the export of all other regions in sector i (except region r) to rest of Turkey. With this fashion, interregional exports can be seen as a contribution of the regions to a pool of commodities available for interregional purchases. The export or import shares of the region in this pool will be used to allocate total interregional imports or exports of a specific region to their region of origin. As we already mention, unfortunately, this dataset does not include the sectoral breakdowns of interregional trade.

Trade and transportation margins enters to the model as a fixed share (ω) of interregional trade flows as in equation (19).

$$\textstyle\sum_s vtwr_{isr} = \omega \,.\; \sum_s Trade_{isr} \tag{19}$$

Here, ω corresponds to the weight of trade and transport margins in interregional trade. This weight can be in two steps. At the first step, share of regional weight in transport sector according to employment data is calculated and then at the second step this total margin for each share is disaggregated to sectors according to national sector specific trade and transport margin use.

Consequently, our efforts in order to build the first Turkish multi-regional SAM finish and the remaining task is to control the row and column sums of the MRSAM. If one finds any inequality especially at the last region, namely bottom rightest region in MRSAM matrix, this can be solved by using again cross entropy method.

distribution of total regional production. First, sector j in region r produces Y_{jr}[3] :

$$Y_{jr} = \sum_j vafm_{jir} + \sum_f vfm_{fir} + Tax_{ir}^{Y} \quad (20)$$

Here $\sum_j vafm_{jir}$ corresponds to total intermediate good ($i = 1 \ldots 8$) used by sector j and $\sum_f vfm_{fir}$ corresponds to regional total of capital and labor factors which is used in sector j to produce i. Factor earnings ($\sum_f vfm_{fir}$) accrue to household. And lastly Tax_{ir}^{Y} goes to government as a taxes on output. Netting domestic production Y_{jr} by regional exports to foreign markets and adding regional imports from foreign markets give the total amount which is available to domestic markets in Turkish economy. The accounting identity for this is like:

$$XD_{ir} = Y_{jr} - X_{ir} + Tax_{i}^{p} + M_{ir} \quad (21)$$

Domestic production XD_{ir} which is netted by foreign trade constitutes the supply side of the economy. On the other hand, regional demand has two components. One is intermediate demand used in production process the other one is final demand constitute of household consumption, public consumption and investment demand. The difference between regional production and regional demand gives us the commodity balance in each region which is already explained in the former chapter. CB_{ir} demonstrates the excess or deficit supply of some goods in each region. At the end of the day, all regions trade with each other and compensate the excess or deficit supply. Already interregional market clearing condition, which will be explained later, require that sum of export of good i in regions equal to the sum of the import of good i from all regions in the model. The accounting identity for this is like following equation:

$$CB_{ir} = XD_{ir} - \left(\sum_j vafm_{jir} + vst_{jr} + vpm_{ir} + inv_{ir} + vgm_{ir}\right) \quad (22)$$

Here vst_{jr} corresponds to the input demand for the production of interregional transport services and vpm_{ir} , inv_{ir} , vgm_{ir} are respectively household demand (C_r), investment demand (I_r) and public consumption (G).

$$\sum_i XD_{ir} - \sum_i CB_{ir} = \sum_{ji} vafm_{jir} + C_r + I_r + G \quad (23)$$

So right hand side of equation above represents the total demand of the region and left

[3] Notation and symbols used in the model algorithm can be seen in Appendix C.

hand side of the equation, namely supply side of the region, satisfies regional demand. Any excess or deficit in the supply side of the region is balanced by interregional trade including transport margins ($vtwr_{isr}$) like the following identity:

$$CB_{ir} = \sum_s Trade_{isr} + \sum_s vtwr_{isr} \tag{24}$$

Here the sum of the input demand of production for the interregional transport services equals transportation and trade margins between regions for the relevant sector j.

$$\sum_j vst_{jr} = \sum_{msr} vtwr_{jmsr} \tag{25}$$

The benchmark identities presented up to here explains all of the market clearance, zero profit and income balance conditions. However, all of these equations do not characterize or represent the behavior of agents in the model. So, the following sections presents the optimization problems of each agent in the model. These are production functions, preferences characterizing the final demand and the representation of trade.

3.1. Production

Production functions in MPSGE programming framework are represented by nested constant elasticity of substitution (NCES) functions. Consequently, profit maximization in the constant returns to scale (CES) setting is equivalent to cost minimization problem like below:

$$\min_{io,K,L} c_{ir}^{io} + c_{ir}^{K} + c_{ir}^{L} \qquad s.t. \qquad c_{ir}^{io} = \sum_i p_{jr}^{A}\, io_{jir}\,, \;\; c_{ir}^{K} = \sum_i p_{ir}^{F}\, K_{ir}\,, \;\; c_{ir}^{L} = \sum_i p_{ir}^{F}\, L_{ir}$$

$$F_{ir}\,(io, K, L) = Y_{ir} \tag{26}$$

$F(.)$ is the production function in cost minimization problem and it is displayed at the Figure 3.1 by a nested CES form.

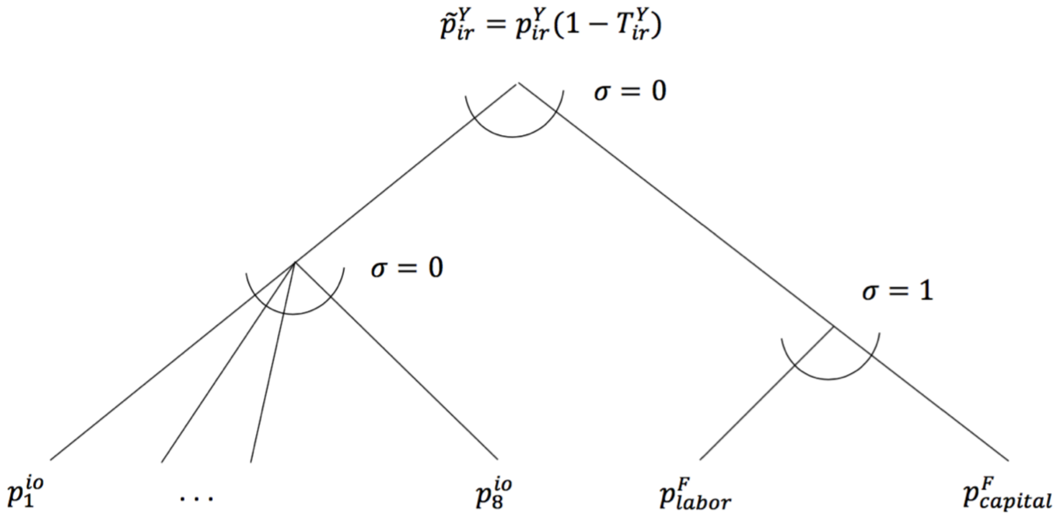

Figure 3.2: Production of the Domestic Good.

Production technology in our model combines intermediate inputs from 8 different sectors with labor and capital inputs. Here, intermediate inputs are not region specific goods and they are simply provided from regional *armington* good pools. So, the unit cost of value-added for each regional sector is simply a CES composite of labor and capital inputs to production, gross of taxes. Marginal cost of supply equals the market price in equilibrium which also lead us to zero profit condition. This will separately be described in the following.

3.2. Final Demand

This block of the model includes the equations which describes the behavior of representative regional household in regions. And the aggregate utility of regional household in region *r* depends on the composite consumer goods. Household will minimize the cost of the aggregate consumption under the budget constraint like below:

$$\min_{C^{HH}_{ir}} \sum_i p^A_{ir}\ vpm_{ir} \qquad s.t. \quad FD_r(vpm_{ir}) = C^{HH}_{ir} \tag{27}$$

Here vpm_{ir} corresponds to household's consumption in each region for each sectors. And C^{HH}_{ir} represents the target consumption level for the regional household. This problem will give minimized level of *Armington* price levels for the targeted level of consumption levels at the end of the day. Since household consumes composite goods which is the aggregated version of imported from rest of Turkey and World and domestic goods produced in the region.

All final demand elements in the model; household consumption, public consumption and investment are characterized by Cobb-Douglas preferences. And the preferences of government and investment will be calculated in this fashion.

3.3. Households' Welfare

Equivalent variation (EV) associated with a policy change can be calculated as in equation 28. Layard and Walters (1978) describes the equivalent variation like

"The equivalent variation is the amount of money one would need to give to an individual, if an economic change did not happen, to make him as well off as if it did."

So, it can be measured as the *monetary change* of benchmark income since it can also be described as the post-simulation utility under benchmark prices (Haddad and Hewings, 2004). And it can be written as in Almeida (2008):

$$EV_r = \left(\frac{U_r' - U_r}{U_r}\right) HHB_r \tag{28}$$

Here, U_r' is the utility after shock, U_r is the benchmark utility and HHB_r is the household's benchmark disposable income. And household's budget is the sum of factor income, net of transfer income from the government including social security incomes (pension), net of foreign income and net of saving income as can be seen from the equation (29).

$$HHB_r = evoa_r + (GTrans_r - Tax_r^H) + (SSI_r - SSP_r) + (Remt_r - Rtrans_r + (SI_r - Sav_r) \tag{28}$$

Lastly, the household demand system in the model, just like other components of the model, requires benchmark values of each regional household's income and expenditure flows.

3.4. Trade

The choice among different goods from different regions in Turkey is based on Armington's idea. The following cost minimization problem will exactly formalizes the idea behind the demand system for different regional commodities:

$$\min_{Trade,Marg} \sum_s (p_{is}^A vxmd_{isr} + \sum_s p_i^T vtwr_{isr})$$
$$+ \ (p_{is}^A vxmd_{i,s=r} + p_i^T vtwr_{i,s=r}) + p_{ir}^{fx} vim_{ir}$$

$$s.t. \qquad A_{ir}(vxmd, vtwr, vim) = Trade_{ir} \qquad (30)$$

A_{ir} is trade aggregation function and it is equal to regional trade in specific sector in each region. This minimization problem will formalize the regional trade behavior in each region at the model. According to this minimization problem, in order to produce a composite commodity, demand for the commodities produced in different regions are described by the CES production function in equation 30.

The cost of transportation in our model enters on a proportional basis with regional trade in each regional commodity. This will also help to reflect the differences between different regional commodities.

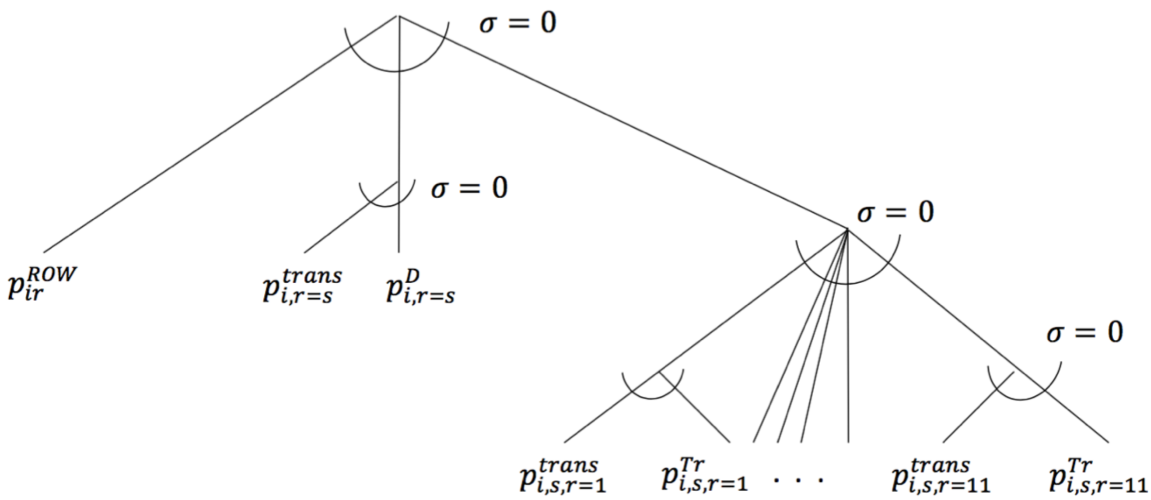

Figure 3.3: Armington Aggregation.

Substitution at the top level of *Armington* composite involves a trading off between imported goods from rest of world, locally produced domestic goods and lastly goods from other regions in Turkey as can be seen from Figure 3.2. Locally produced domestic goods and imported goods from other regions in Turkey are associated with transportation services and these services are fixed share of traded goods as explained in former part. And the allocation of the output from the supply perspective can be seen at Figure 3.3.

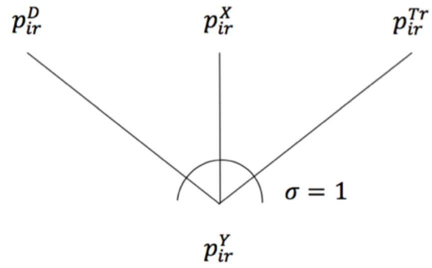

Figure 3.4: Allocation of the Output (Trade).

3.5. Transportation Services

The commodity produced locally or imported from other regions will be first merged into a local commodity pool via transport sector, and then the producers and household in that region will obtain goods from that local commodity pool. This is the mechanism behind the transport sector and local commodity pools. At the context of the model, these pools for each commodity exist in each region. The movement of the commodity between the producer and the imaginary commodity pool is enabled by a transport sector at a certain cost. Consequently, relevant commodity will have two different prices in each region: one of them is the supply price which is also known as producer price; and the other one is the demand price which the final or intermediate users pay for purchasing the commodity. Transport sector, to produce transport services, pays for buying some commodities from producers in other sectors, while transport sector charges other producers for selling the transport services. In this sense, a transport sector can be gauged as an agent and also can be viewed as a retailer in the model framework.

In this sense, transportation services will have its own block in the model algorithm. It will produce its output according to a regional resource- demanding optimizing problem. The explicit modeling of such a transportation services based on the movements in origin destination pairs represents a major theoretical advance (Isard *et al*., 1998), even if it makes the model structure rather complicated and difficult to implicate (Bröcker, 1998). The model was calibrated by taking into account the transportation cost of each commodity flow which is based on regional transportation infrastructure efficiency. With this feature, space will play a major role and any improvement in the network infrastructure will effect the efficiency of the transportation sector. This is modeled to take this detail into account in the model algorithm. It will also be introduced in transport sub module section in the conclusion part of this thesis. Lastly, regional transportation sectors are assumed to operate under constant returns to scale using as inputs composite intermediate goods and capital and labor like in the other production sectors.

We will assume that transport costs are paid at the origin of shipment. And transportation demand will be derived from purchases of other commodities. Transport sector will also seek to minimize costs given the level of services.

In MPSGE context, transportation services are modeled through an aggregation of transportation for each commodity in each region. So a cost minimization problem here will be employed for transportation and trade services between regions like in the following formula:

$$\min_{margin} \sum_r p_{ir}^T vst_{ir} \qquad s.t. \quad T_r(vst) = Transport_r \tag{31}$$

vst_{ir} denotes the cost of shipping one unit of commodity i from region r to regions s. T_r here denotes the aggregation function which combines all transport services for each commodity in each region. In TurksCGE model, there exist 8 different transport services which carry 8 different commodities between regions. Since the share of transportation services in different commodities are different, this has been seen as a necessary step in the model. We defined technology and preferences/demand systems in the model. Now we need to define the market clearance conditions in the model.

3.6. Equilibrium Conditions

The variables in this section are defining an equilibrium. And these are activity levels (for constant-returns-to-scale firms) and commodity prices verifies the equilibirum. In equilibrium, the aggregate supply of each good must be at least as great as the sum of intermediate and final demand. This is the key rule in this part. In the following, we will detail zero profit conditions, market clearance conditions, and income balance conditions.

3.6.1. Zero profit condition

All sectors in the model are activating by constant returns to scale technologies. And markets are assumed to operate competitively with free entry and exit. Consequently, firms' profits are driven to zero in equilibrium because of the assumption of free entry and constant return. And the price of output will reflect the cost of inputs since the price is equal to marginal cost.

The value of output to the firm equals the value of sales in the domestic and foreign markets and also total cost of the production of relevant good. Equation 32 reflects this.

$$(p_{ir}^{D} XD_{ir} + p_{ir}^{X} vxm_{ir}) = \sum_j vafm_{jir} + \sum_f vfm_{fir} + Tax_{ir}^{Y} \qquad (32)$$

3.6.2. Market clearance

- *Armington Aggregate Supply*

Domestic supply, which constitute of regional production available to domestic market after export and import from other sector within Turkey and imports from rest of the world equals intermediate and final demand:

$$XD_{ir} + \sum_s Trade_{isr} + \sum_s vtwr_{isr} + vim_{ir} = \sum_j vafm_{jir} + vst_{jr} + vpm_{ir} + inv_{ir} + vgm_{ir} \qquad (33)$$

- *Trade*

Sum of export supplies for each good equals total import demand from all regions within Turkey plus demands for interregional transport:

$$\sum_s vxma_{isr} + \sum_s vtwr_{isr} = \sum_r vxma_{irs} + \sum_r vtwr_{irs} \qquad (34)$$

- *Primary factors*

Labor and capital endowment equals primary factor demand:

$$\sum_i F_{fir} = \sum_i Y_{ir} \alpha_{fir}^{F} \qquad (35)$$

Here, $\sum_i F_{fir}$ reflects the total fator endowment in the sector *i* and right hand side of the equation reflects the share of factor α_{fir}^{F} in the production good *i* .

3.6.3. Income and expenditure

Private and public incomes and expenditure accounts including investment demand and its budget are given by the following equations. All of these identities verifies the income and expenditure balances in the Turkish Spatial CGE model:

- Private Demand and its budget:

$$HHB_r = evoa_r + (GTrans_r - Tax_r^H) + (SSI_r - SSP_r) + (Remt_r - Rtrans_r) + (SI_r - Sav_r) \quad (36)$$

$$HHB_r = \sum_i vpm_{ir} = C_r \quad (37)$$

- Public Demand and its budget:

$$R = \left(\sum_r T_r^Y + T_r^p + T_r^H\right) + Gbor - \left(\sum_r Gtrans_r + \sum_r SSIdef\right) - Gsav \quad (38)$$

$$R = \sum_{ir} vgm_{ir} = G \quad (40)$$

- Investment Demand and its budget:

$$Inv_r = Sav_r + Gsav + Fsav \quad (41)$$

$$Inv_r = \sum_i inv_{ir} = I_r \quad (42)$$

New investments in the model are designed to be financed by consolidated savings, including private domestic savings, government savings, and foreign savings, according to Equation 41.

4. EMPIRICAL RESULTS

Since our model is static, presentation of the results in this section will focus on the short-run effects and the impacts on the longer-run (for example capital and labor are free to move between regions) will be above the scope. Attention will be directed to the important aggregate variables in the first step and then we will get into the details of spatial effects which especially considers changes in welfare and regional GDP.

Before mentioning the results of the simulations, we need to emphasize the driving forces that work inside the model. According to this, a decrease in transportation costs between two or more regions will have effects on price level and the interregional allocation of resources since transportation costs effect directly the final price of goods.

When we get further into details of the intuition behind this mechanism, any enhancement in transportation network will reduce the cost of production of the transportation sector in relevant region or regions which new route pass trough. As the transportation sector becomes more efficient, transportation sector as a margin industry will reduce unit cost of other industries.

On the the hand, transportation cost reduction will also increase households' welfare by generating a decrease in pool/*armington* prices and increasing households' real income. If we look at this process from the production side, total output will increase as a result of savings in transport costs which will lead to lower prices and more demand. Any increase in final demand will feed the production side of the economy and lead to an increase in the output level of firms. Since firms produce more, they have to purchase more primary factors. Increasing demand in primary factors will cause the prices of these factors go up and once again household real income will increase.

Another important effect of decreasing prices that we need to emphasize is the *substitution effect* in trade flows between regions. For example, purchasing some goods from region A can be less expensive for region B and therefore, region A can export more goods to region B. At the end of the day, regions which have lower production costs will tend to increase their market share within the economy. This is the *substitution effect* and any change in transport cost will affect regional market shares by lowering the relative prices of relevant region.

All of these effects of new highways will be reflected in welfare and efficiency gains in regional level. Spatial CGE model we constructed in this study is capable to see all of these results.

4.1. Simulations

In this section, we use the model that we described in the former chapter to simulate the impacts of reduced inter-regional transportation costs. Starting from the point when Izmir-Istanbul highway project toward second group of target projects of Turkish government, we will handle three main counterfactual experiments. 10 different highway projects which is both under construction and also planned towards 2023 targets of Turkey has been aggregated according to groups explained by General Directorate of Highways of Turkey. And highway investments simulated will be as in the government's plan:

Experiment 1: Izmir – Istanbul highway project
Experiment 2: First group target projects
Experiment 3: Second group target projects

We evaluate three experiments which is shown like above. First experiment covers only Izmir-Istanbul highway project under construction (blue line at Figure 4.1.). First group of highway porjects include all yellow line at Figure 4.2., i.e., Canakkale Bridge and Tekirdag-Canakkale-Balikesir highway, Nigde-Ankara Highway and lastly Antalya-Alanya highway. Second group of highway projects include all grey lines at Figure 4.3., covering important links between from north to south and from east to west. All of the scenarios in this thesis based on the links specified in master plans of General Directorate of Highways and they can be seen at the below maps.

Lastly, this study considers the interregional trade of goods within the study area but ignore the trade with the rest of country as well as international trade. And trade and transportation margins enters to the model as a fixed share of interregional trade flows as in Equation (19). Taking this fact into account, policy shocks which is based on the changes in interregional trade and transport margins will be calculated by a network route choice model. And these results will feed the model in the part of the measure the severity of policy shock. In this context, tolls and network congestion are not taken into consideration.

Changes of margins after the new route or improvement in the network will be the linear function of distance between regions as an assumption. And percentage changes of these margins will be captured via a module which is an extension to our multi-regional CGE model. According to Probelli et al. (2010), formal consideration of nodes in a transportation network is required if the full implications of transport investments are to be considered in a spatial CGE models. That is what we did in our study. These computations have been done by following Dantzig's (1957) shortest path problem that is phrased as a linear programming problem. This algorithm has been run in GAMS and used its outputs in the core CGE model. All of these shocks which calculated according to transportation module can be seen at the following three Tables.

Table 4.1: Calculated decreases in distances for each origin-destination pairs for the Experiment 1.

	Istanbul	Mar.	Izmir	Aegean	Ankara	Central Ana.	Medite.	S. East	East Ana	West B. Sea	East B. Sea
Istanbul											
Marmara	0.053	0.087									
Izmir	0.175	0.163									
Aegean	0.063	0.287	0.066	0.043							
Ankara		0.211	0.017								
Central Ana.		0.082	0.016								
Mediter.		0.051	0.015								
South East		0.029	0.008								
East Ana.		0.099	0.008								
West B. Sea		0.174	0.04	0.05							
East B. Sea		0.093	0.007								

Table 4.2: Calculated decreases in distances for each origin-destination pairs for the Experiment 2.

	Ist.	Mar.	Izmir	Aegean	Ankara	Central Ana.	Mediter	South East	East Ana	West B. Sea	East B. Sea
Istanbul											
Marmara	0.053	0.087									
Izmir	0.181	0.174									
Aegean	0.078	0.367	0.088	0.156							
Ankara		0.288	0.096	0.123							
Central Ana.	0.019	0.322	0.041	0.141	0.051	0.213					
Mediter.	0.034	0.431	0.030	0.155	0.031	0.137	0.07				
South East	0.006	0.155	0.010	0.034	0.033	0.089					
East Ana.		0.122	0.043	0.046		0.071	0.022	0.004			
West B. Sea		0.199	0.076	0.121		0.196	0.091	0.019			
East B. Sea		0.113	0.038	0.041		0.123	0.036				

Table 4.3: Calculated decreases in distances for each origin-destination pairs for the Experiment 3.

	Ist.	Mar.	Izmir	Aegean	Anka	Central Ana.	Mediter	South East	East Ana	West Black Sea	East Black Sea
Istanbul											
Marmara	0.053	0.095									
Izmir	0.181	0.190									
Aegean	0.078	0.418	0.088	0.156							
Ankara		0.446	0.096	0.123							
Central Ana.	0.032	0.559	0.055	0.158	0.051	0.213					
Mediter.	0.099	0.266	0.065	0.591	0.090	0.339	0.215				
South East	0.036	0.327	0.010	0.034	0.048	0.115	0.030	0.128			
East Ana.	0.05	0.522	0.068	0.238	0.041	0.311	0.185	0.312	0.062		
West B. Sea	0.071	0.723	0.103	0.331	0.061	0.547	0.308	0.158	0.289	0.197	
East B. Sea	0.061	0.561	0.066	0.238	0.045	0.339	0.249	0.506	0.245	0.080	

As we mention before, all of these distance shortenings as a result of new highways addition to network will be used to calculate new transportation margins for the interregional trade flows. Proposed investments in first and second group of highway projects will have more network effect as can be seen from the last two Table 4.2 and Table 4.3.

Experiment 1

For the first experiment, results indicate that all regions experience increases in wages as well as in capital rents, which will also constitute the positive effects on regional incomes. According to Haddad et al. (2008), improvement in transportation network will reduce the cost of production of the transportation sector in the related region. As a margin industry, this cost reduction in transport sector will reduce also the unit cost of other industries through their transportation cost component. This will eventually increase the marginal productivity of labor and capital, making it profitable to hire labor and capital from the initial price levels. Subsequently, increased demand for capital and labor will increase the real prices of capital and labor. Seemingly, the increase in the real prices of primary factors in Marmara region is relatively higher. This can also mean that labor force migrates to this region relatively in higher level but this kind of implications are above the scope of this analysis since we are not able to control demographic variables in this model.

In particular, the Marmara region (not including Istanbul) experiences the largest impact in terms of welfare gain and regional GDP, due to the increased access to the economically large Istanbul region. Second is Istanbul which gains the most from this new highway. And also we found that Istanbul was evaluated as the most efficient for boosting GDP among the three largest cities. Aegean region (not including Izmir) seem to benefit more then Izmir in terms of GDP and welfare. Cities in both Marmara region and Aegean region are comparatively less developed according to Istanbul and Izmir. And these results indicate that households in less developed regions appear to benefit more with better access to economically larger cities. According to Haddad and Hewings (2008), the mechanism behind this intuition can be summarized as lower transport costs will cause greater volume of goods to be available at lower prices in less developed regions. As a result, regional welfare will eventually increase by the availability of greater variety of goods and services in less developed regions.

Table 4.5: Regional results of the first experiment.

	Pool Goods Prod.	Household Cons.	Final demand	Capital	Wages	GDP	Welfare
Istanbul	0.5 %	0.6 %	0.3 %	0.8 %	0.8 %	0.8 %	0.8 %
Marmara	0.3 %	1.3 %	0.1 %	1.4 %	0.1 %	1.1 %	1.2 %
Izmir	0.4 %	0.3 %	0.3 %	0.6 %	0.4 %	0.5 %	0.6 %
Aegean	0.3 %	0.6 %	0.3 %	0.7 %	0.8 %	0.7 %	0.7 %
Ankara	0.1 %	0.2 %	0.01%	>0.01%	> 0.01%	>0.01%	>0.01%
Central Ana.	0.4 %	0.1 %	0.3 %	0.4 %	0.4 %	0.4 %	0.4 %
Mediterranean	0.1 %	>0.01%	0.1 %	0.1 %	0.1 %	0.1 %	0.1 %
Southeast	0.2 %	>0.01%	0.2 %	0.1 %	0.2 %	0.2 %	0.2 %
East Anatolia	0.4 %	0.1 %	0.3 %	0.4 %	0.5 %	0.4 %	0.4 %
West Black Sea	0.3 %	0.1 %	0.3 %	0.3 %	0.4 %	0.3 %	0.4 %
East Black Sea	0.4 %	0.1 %	0.3 %	0.3 %	0.6 %	0.3 %	0.4 %

Regarding the spatial results for the first scenario, Marmara region once more gains the most in terms of welfare (1.2 %) as can be seen in Figure 4.6. Istanbul, Izmir and Aegean region experience welfare gain in similar level ranging between 0.6% – 0.8% (see Table 4.5). This welfare gain is due to two effects. If we take the region with most gain, for Marmara region, from the production side, an improvement in transportation network allows firms in this region to raise their output as a result of better access to intermediate inputs and final product markets by augmenting the wages 1.4% and capital rents by 1%. At the end of the day, this increase in factor markets enables households to have more income. This is the first part of the story behind the why Marmara regions gains the most. From the consumption side, since transportation margins gets lower because of the the road network improvements, pool prices decreases. This effects the real incomes of households to increase. These two effects cause an increase in the demand of households by 1.3 % in Marmara region and an increase in the *armington* goods by 0.3%.

Table 4.8: Regional results of the second experiment.

	Pool Goods Prod.	Household Cons.	Final demand	Capital	Wages	GDP	Welfare
Istanbul	0.6 %	0.8 %	0.3 %	0.9 %	0.8 %	0.9 %	0.9 %
Marmara	0.5 %	1.4 %	0.2 %	1.6 %	1.2 %	1.4 %	1.5 %
Izmir	0.6 %	0.4 %	0.5 %	0.8 %	0.7 %	0.8 %	0.8 %
Aegean	0.8 %	2.3 %	0.3 %	2.2 %	2.5 %	2.1 %	2.2 %
Ankara	0.2 %	0.5 %	>0.01%	0.2 %	0.2 %	0.3 %	0.3 %
Central Ana.	>0.01%	2.9 %	-0.5 %	1.6 %	1.7 %	1.5 %	1.6 %
Mediterranean	0.2 %	1.7 %	-0.2 %	1 %	1 %	1 %	1 %
Southeast	0.5 %	0.4 %	0.3 %	0.5 %	0.7 %	0.6 %	0.6 %
East Anatolia	0.8 %	0.3 %	0.5 %	0.8 %	0.9 %	0.8 %	0.9 %
West Black Sea	0.6 %	0.3 %	0.5 %	0.8 %	0.9 %	0.8 %	0.9 %
East Black Sea	0.6 %	0.4 %	0.3 %	0.6 %	1.1 %	0.7 %	0.8 %

We found that Izmir itself as a big city was evaluated as the most efficient for boosting GDP among the three largest cities in this experiment. But again Aegean region (not including Izmir) and Central Anatolia (not including Ankara) seem to have a better performance then Izmir and Ankara in terms of GDP and welfare gains. Cities in both Central Anatolia region and Aegean region are comparatively less developed according to Ankara and Izmir and these results indicates once more that households in less developed regions with better access to economically bigger cities appear to be better off. Regional welfare will be enhanced by the greater volume of goods being available at lower prices in less developed cities because of the transportation enhancement.

In this experiment, Aegean and Central Anatolia regions are outstanding according to our model results and if we look at the insight into the sectoral details, Agriculture sector is the key sector if transportation sector was not taken into account. Again, transportation sector increases its output more comparing to other sectors in regions.

Table 4.9: Output Change in each Regional Sector.

	Agri.	Food	Textile	Const.	Trans.	Mach.	Oth.Ind.	Service
Istanbul	0.6 %	0.3 %	0.7 %	0.4 %	0.9 %	>0.01 %	0.4 %	0.6 %
Marmara	1 %	0.3 %	-0.02%	0.4 %	1.5 %	-0.2 %	0.3 %	1 %
Izmir	0.7 %	0.5 %	0.4 %	0.5%	0.8 %	0.2 %	0.5 %	0.6 %
Aegean	1.3 %	0.6 %	-0.6 %	0.5 %	2.2 %	-0.1 %	0.1 %	1.4 %
Ankara	0.2 %	0.01 %	-1.2 %	0.3 %	0.2 %	0.1 %	0.2 %	0.2 %
Central Ana.	0.5 %	-0.04 %	-2.9 %	-0.3 %	1.5 %	-1.8 %	-0,8 %	0.7 %
Mediter.	0.4 %	-0.02%	-1.4 %	>0.01%	0.9 %	-1%	-0,2 %	0.5 %
South East	0.4 %	0.2 %	0.1 %	0.5 %	0.5 %	0.4 %	0.5 %	0.5 %
East Ana.	0.8 %	0.7 %	0.2 %	0.6 %	0.8 %	0.4 %	0.8 %	0.8 %
West B.Sea	0.7 %	0.6 %	0.5 %	0.4 %	0.8 %	0.2 %	0.5 %	0.7 %
East B. Sea	0.6 %	0.5 %	0.2 %	0.5 %	0.7 %	0.3 %	0.7 %	0.7 %

Regarding the sectoral level results for the second scenario, in value basis, increase in agriculture value added is TL559.7 million in Aegean region which increases its regional GDP by 2.1%. And it is TL162.8 million per year for Central Anatolia and TL515.2 million for Marmara. Eastern part of Turkey, namely, East Black Sea, East Anatolia and South East regions increases their industrial output (other industry segment which excludes food, textile and machinery). It is TL75.4 million in East Black Sea, TL117.3 million in East Anatolia and TL138 million in South East Anatolia. These regions increase also their output in agriculture (TL424.1 million in total) and food sectors (TL166.9 million in total) with the help new routes in western part of Turkey.

Table 4.10 reveals the spread effects of the first tier highway projects on the different regions. As can be seen, positive effects of the interregional trade presented in most of the regions. Lower value of transport costs from related regions, that account for a considerable part of interregional trade. Again, since we don’t have interregional backward linkages, it is very difficult to say which sector in a given region experience a higher trade flows.

Table 4.10: Effects of first tier highway projects on interregional trade.

	Istanbul	Marmara	Izmir	Aegean	Ankara	Central Ana.	Mediter.	South East Ana.	East Ana.	West Black Sea	East Black Sea
Istanbul		1.069	1.102	1.004	0.984	0.984	0.951	1.002	1.003	1.011	1.032
Marmara	1.088		1.061	0.774	1.006	0.781	0.967	1.058	1.114	1.012	1.126
Izmir	0.970	1.045		0.782	1.017	1.210	0.959	1.068	1.073	1.010	1.126
Aegean	1.053		1.056		1.008	0.780	0.969	1.063	1.100	1.035	1.037
Ankara		1.071	1.066	1.003		0.954	0.952	0.978	0.972	0.974	0.966
Central Ana.	0.988		1.051	0.772	1.012		0.968	1.068	1.065	1.004	1.074
Mediterranean	1.049	1.071	1.057	1.003	1.007	0.954		0.978	0.972	0.974	1.021
South East A.	1.033	1.045	1.056	0.946	1.028	1.210	0.956		1.076	1.177	1.082
East Ana.	1.049	1.002	1.056	0.943	1.007	1.210	0.941	1.002		0.983	1.025
West B. Sea	0.985	1.002	1.092	0.941	0.967	0.946	0.951	1.027	1.021		1.015
East B. Sea	0.909	1.045	1.023	0.943	1.015	0.933	0.970	1.068	1.045	1.035	

Experiment 3

In this experiment, we will analyze the effects of new highway projects mostly in east part of Turkey which is comparatively less industrialized and has lower per capita income. According to General Directorate of Highways target projects which is in the second group, except Bursa-Antalya highway connecting Marmara to Mediterranean through Aegean region, all other project connects comparatively less developed regions of Turkey to each other. Rize-Mardin highway project which includes one of the longest tunnel (Ovit) is connecting the East Black Sea region to South East region and enabling to travel in less time consuming way and in a shorter route. This route connects geographically one of the hardest regions in terms of traveling from one point to another. Another two projects in this group is connecting north of Turkey to Central Anatolia and also East Anatolia regions. Consequently, this experiment covers the projects which we expect to see more welfare and efficiency gains in eastern part of Turkey.

Regarding the spatial results for the third scenario, in terms of GDP growth, in the short run, there appear clearly highest regional GDP increases in the Turkish economy. Table 4.9 below reports the impact of these investment on different variables.

Table 4.11: Regional results of the third experiment.

	Pool Goods Prod.	Household Cons.	Final demand	Capital	Wages	GDP	Welfare
Istanbul	0.6 %	0.9 %	0.3 %	1.1 %	0.9 %	1 %	1 %
Marmara	0.7 %	1.6 %	0.2 %	1.9 %	1.4 %	1.7 %	1.8 %
Izmir	0.7 %	0.5 %	0.6 %	1 %	0.8 %	1 %	1 %
Aegean	1 %	2.4 %	0.5 %	2.4 %	2.6 %	2.4 %	2.5 %
Ankara	0.3 %	0.9 %	0.1 %	0.5 %	0.5 %	0.6 %	0.6 %
Central Ana.	0.3 %	3.2 %	-0.4 %	2.1 %	2.2 %	2 %	2.1 %
Mediterranean	0.6 %	4.6 %	-0.7 %	2.8 %	2.8 %	2.7 %	2.8 %
Southeast	1.5 %	3.6 %	0.5 %	3.1 %	3.5 %	3.1 %	3.2 %
East Anatolia	0.9 %	2 %	0.1 %	1.7 %	1.7 %	1.7 %	1.8 %
West Black Sea	0.1 %	2.9 %	-0.6 %	1.6 %	1.7 %	1.6 %	1.7 %
East Black Sea	0.7 %	1.2 %	0.2 %	1 %	1.6 %	1.2 %	1.3 %

If we look at the sectoral value added side of this experiment, we see that transportation sector is again the first sector which derives more benefit from the highway network development.

Regarding the sectoral level results for the third scenario, in value terms, in the short run, there appear a substantial increase on agricultural value added in Mediterranean, Marmara, Aegean and South East Regions. For example, the increase on the value added of the agricultural sector in Mediterranean is TL712.5 million. With the new routes which connects Mediterranean region to agriculture demanding regions such as Istanbul, Mediterranean Region is the most increasing region its agricultural output in value basis. Second is the Aegean region and it is TL641.2 million. Marmara and South East region increase their agricultural value added by TL632.3 million and TL507.6 million. Agricultural output increase in South East Region is above the increase in Central Anatolia (TL283 million) which is agricultural hub of Turkey.

Again, there is a shift towards the production of transportation services, as expected. And transportation sector increases its output more comparing to other sectors in regions. The effect on the value added of the food, textile and machinery sectors in some regions seem like negative even if it is very small. For textile sector, we can say that production increases in Istanbul (TL591.4 million) and Izmir (TL65.5 million) while decreasing in Central Anatolia (TL223.3 million), Mediterranean (TL511.5 million), South East (TL248.7 million) and Aegean (TL81.7 million). According to all of synergy effects with new addition to transportation network, Izmir and Aegean regions increases their Food sector output by TL114 million and TL 162.6 million respectively. We see a decrease in industrial production in West Black Sea (TL178 million), Mediterranean (TL556.1 million) and Central Anatolia (TL295.6 million) while Istanbul (TL607 million), Marmara (TL674.7 million), Izmir (TL258.7 million), Aegean (TL139.3 million) and South East (TL139.9 million) increases their industrial value added.

All of these results in value added indicates the GDP increases in regions in different volume. As can be seen at the Table 4.10, with the increase in sectoral value added, especially in Transportation, Agriculture and Other Industry (which excludes food, machinery and textile) sectors, regional GDP increases 3.2% in South East region and

2.8% in Mediterranean region. Regional GDP increase for giant city Istanbul is 1%.

Lastly, New routes at second package of highway projects are existing in geographically difficult locations. And These regions, i.e., East Black Sea, East Anatolia, South East Anatolia and Mediterranean regions which gains the most in this experiment, are the regions which both land is not flat comparing to other regions of Turkey and also accessibility to inland regions and big cities are comparatively low. Even if we don't control the distance in our margin calculations, the weight of the trade flows between regions are still similar to actual picture[1]. Here, the rationale of the experiment is to 'bring nearer' these farther regions to the richer regions. In this sense, such a phenomenon has an important impact to enhance economic integration (Bröcker, 1998). It seems the poorer regions capture all benefits at the expense of the richer regions (Figure 4.8) just like in our other other experiments.

In sum, the results demonstrate the ability of the model to capture regional impacts. The results suggest that increased productivity of transportation services, while having a positive aggregate impact on the overall economy that we tried to show at the beginning of this chapter, may also contribute more to some regions which gets closer to richer cities and regions. But at the end of the day all regions may end up as winners.

Table 4.13 reveals the spread effects of the second tier highway projects on the different regions. As can be seen, positive effects of the interregional trade presented in most of the regions. Lower value of transport costs from related regions, that account for a considerable part of interregional trade. Again, since we don't have interregional backward linkages, it is very difficult to say which sector in a given region experience a higher trade flows.

[1] This data includes the actual trade flows between cities in Turkey for the year 2015. Since this data doesn't disaggregate the margins and taxes from the basic prices of goods, we used a nonsurvey method to calculate these flows and margins that we described in MRSAM chapter.

4.13: Effects of second tier highway projects on interregional trade.

	Istanbul	Marmara	Izmir	Aegean	Ankara	Central Ana.	Mediter	South East Ana.	East Ana.	West Black Sea	East Black Sea
Istanbul		1.108	1.132	1.032	1.095	1.131	0.872	1.015	1.047	1.003	1.058
Marmara	1.097		1.074	0.849	0.983	0.830	0.897	0.993	0.992	0.834	1.071
Izmir	0.834	1.314		0.862	1.013	1.524	0.823	1.069	0.839	0.764	1.075
Aegean	1.057		1.065		1.007	0.830	0.913	1.035	1.038	0.973	1.038
Ankara		1.095	1.090	1.005		1.108	0.825	1.027	1.029	0.955	0.992
Central Ana.	0.985		1.058	0.848	1.017		0.903	1.069	0.886	0.788	1.051
Mediterranean	1.047	1.095	1.066	1.005	1.007	1.108		1.027	1.029	0.955	1.028
South East A.	1.026	1.314	1.064	1.097	1.081	1.524	0.870		0.965	1.145	1.084
East Ana.	1.047	1.005	1.065	0.955	1.007	1.524	0.660	1.014		0.835	1.034
West B. Sea	0.983	1.005	1.114	0.969	1.006	0.980	0.865	0.999	1.052		1.056

5. CONCLUSION

In this thesis, the integrated transport–Multi Regional CGE model is developed to assess the spatial economic effects of 10 highway projects out of targeted highway projects until 2023 (100th anniversary of Republican Turkey). The model we handle in this thesis captures the effects of infrastructure improvements at both micro and macro economic level and also regional level.

Regarding the impacts of new highway projects on household welfare in different regions, it seems that households in less developed regions with better access to economically bigger cities appear to be better off. The mechanism behind this inference based on the fact that lower transport cost results in a greater volume of goods being available at lower prices in less developed cities by bringing nearer these farther regions to the richer regions

In that sense, big cities like Istanbul, Izmir and Ankara experience less welfare gain and efficiency enhancement. For instance, Marmara region appear to gain more then Istanbul and also Aegean region which is neighbor of Izmir gains more then Izmir in the first experiment which covers Istanbul-Izmir highway project. This fact appears also in our other two experiments.

From the same perspective, the first and second group of targeted highway packages which covers the projects subsequently in West and East of Turkey, new highway corridors can increase regional GDPs and consequently reduce the regional income disparities according to our model results. For instance, first group of targeted highway projects which covers the new connections mainly between Aegean and Central Anatolia with Izmir-Ankara highway project and also Ankara-Nigde highway project which South East region enables access to inland and western regions, Aegean and Central Anatolia regions are outstanding in this experiment. And also third experiment reveals the same result. Relatively poorer cities in South East region benefit more than the richer ones in relative terms since eastern cities experience an increase in accessibility with the new routes.

On the other hand, last experiment covers the calculation of the network effect of all targeted project of Turkey on the way of 2023. Since highway projects are connected to each other in all over the Turkey, third experiment covers the summing of net increase in the GDP and welfare from the development of all proposed highway projects over the three scenario with the spatial linkage. At this experiment, results reveal the largest increase on almost all variables. In particular, South East region benefit the most suggesting that the poorer regions may catch-up in this simulated environment. In a multiregional economic perspective, this regional enhancement in almost all variables is expected to contribute to the economic cooperation of remote regions like South East and East Black Sea regions.

It is important to underline that the results in this thesis are part of a counterfactual analysis. And the results obtained are based on a given structure of the economy in 2015 which is base year of the model. So the model does not consider other structural changes or future economic events. Given this fact, the goal of this paper was to contribute to a better understanding of the behavior of regional price and quantity changes which will eventually effect the variables like income, consumption and production. Also, this thesis aims to contribute in the point of presentation of the Multi Regional CGE model for Turkey, which brings in detailed analysis in sectoral and regional aspects. This thesis also contributes to the literature by building a Multi Regional Social Accounting Matrix which enables Multi regional CGE models.

For Further Research

This thesis starts an exploration of the Turkish economy using a Multi Regional Computable General Equilibrium model context. First step was the exploration of the impact of transportation investments, the success story. The process is on-going and difficult because attempts to handle different issues necessitates various kind of different data in regional level and bringing the details to convenient format is time consuming.

At this point, a couple of points should be mentioned for further research. One is that the integrated transport–module can be transformed into a transportation sub model which calculates all margins between regions within the sub model. The margins we used in this thesis is the fixed share of interregional trade flows. Another one would be to take into account the transportation margins for export. Since lower transportation cost in the trade with neighbor countries may change the economic benefits of different highway projects. And the network effect may be much larger when this detail is included to model.

The model presented in the thesis incorporates the effects of transport infrastructure improvements in only interregional trade part. The welfare benefits calculated in the presented model are not complete, since they do not capture any of effects on private car traveling. No doubt, shortening distances contributes to total time spent on the road. If we take into account this factor in household budget constraint, welfare benefits would even higher. In this fashion, we can also analyze the spatial effects of different modes like high speed rail and airports. Because these investments mostly have direct impact on traveling time of households.

In spite of these obstacles and drawbacks, this study contributes to measuring of different transport investments to the economy.

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APPENDICES

Appendix A: Regional Decomposition Table.

Appendix B: Interregional Trade Flows (in millions TL).

Appendix C: Set Definitions.

Appendix D: Definition of activity levels and price variable.

Appendix E: Project definitions and cumulative results by project order.

Appendix A: Regional Decomposition Table.

Regions in TurkMRSAM	Subregions (NUTS 2)	Cities (Nuts 3)
Istanbul	Istanbul Subregion	Istanbul Province
Marmara Region	Tekirdag Subregion	Tekirdag, Edirne, Kirklareli
	Balıkesir Subregion	Balikesir, Canakkale
	Bursa Subregion	Bursa, Eskisehir, Bilecik
	Kocaeli Subregion	Kocaeli, Sakarya, Duzce, Bolu, Yalova
Izmir	Izmir Subregion	Izmir Province
Aegean Region	Aydın Subregion	Aydin, Denizli, Mugla
	Manisa Subregion	Manisa, Afyon, Kutahya, Usak
Ankara	Ankara Subregion	Ankara Province
Central Anatolia Region	Konya Subregion	Konya, Karaman
	Kirikkale Subregion	Kirikkale, Aksaray, Nigde, Nevsehir, Kirsehir
	Kayseri Subregion	Kayseri, Sivas, Yozgat
Mediterranean Region	Antalya Subregion	Antalya, Isparta, Burdur
	Adana Subregion	Adana, Mersin
	Hatay Subregion	Hatay, Kahramanmaras, Osmaniye
West Black Sea Region	Zonguldak Subregion	Zonguldak, Karabuk, Bartin
	Kastamonu Subregion	Kastamonu, Cankiri, Sinop
	Samsun Subregion	Samsun, Tokat, Corum, Amasya
East Balck Sea Region	Trabzon Subregion	Trabzon, Ordu, Giresun, Rize, Artvin, Gumushane
East Anatolia Region	Erzurum Subregion	Erzurum, Erzincan, Bayburt
	Agri Subregion	Agri, Kars, Igdir, Ardahan
	Malatya Subregion	Malatya, Elazig, Bingol, Tunceli
	Van Subregion	Van, Mus, Bitlis, Hakkari
Southeast Anatolia	Gaziantep Subregion	Gaziantep, Adiyaman, Kilis
	Sanliurfa Subregion	Sanliurfa, Diyarbakir
	Mardin Subregion	Batman, Sirnak, Siirt

Appendix B: Interregional Trade Flows (in millions TL).

	Istanbul	Marmara	Izmir	Aegean	Ankara	Central Anatolia	Mediterranean	South East	East Anatolia	West Black Sea	East Black Sea	Export to Rest of Turkey
Istanbul	0	86.9	21.9	42.7	41	47.3	43.9	48.9	38.3	27.4	22.9	421.2
Marmara	131.8	0	2.3	3.5	6	2.2	7.7	4.9	2.5	1.9	1.3	164.1
Izmir	38.6	4.2	0	1.2	1.3	1.1	1.6	1.3	0.9	0.9	0.5	51.6
Aegean	28.7	1.7	1.5	0	3.2	0.3	1.4	1.1	0.3	0.2	0.8	39.2
Ankara	45.4	6.2	0.6	2.4	0	2.7	1.4	1.9	1.8	2.1	1	65.5
Central Anatolia	28.8	1	1.3	0.3	3.1	0	1.3	1.1	0.2	0.1	0.7	37.9
Mediterranea	23.9	1.4	1.3	0.5	2.3	0.5	0	7.7	0.4	0.4	1	39.4
Soth East	30.2	0.7	0.9	0.2	1.8	0.2	0.8	0	0.2	0.1	0.5	35.6
East Anatolia	19.9	0.1	0.6	0.06	1.1	0.05	0.5	0.2	0	0.02	0.2	22.7
West Black Sea	22.1	0.7	0.7	0.3	1.3	0.2	0.7	0.4	0.09	0	0.3	26.8
East Black Sea	17.2	0.3	0.1	0.07	0.6	0.05	0.6	0.5	0.02	0.07	0	19.5
import from Rest of Turkey	386.6	103.2	31.2	52.1	62.1	54.6	59.9	68	44.71	33.19	29.2	

Appendix C: Set definitions.

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r or s = 1,....,*R*   denote 11 regions in the model. And these are an aggregation of 81 cities of Turkey except 3 biggest cities; Istanbul, Ankara and Izmir each is a separate unique regions

j   denotes sectors, aggregated 8 sectors in the Input-Output tables

i   denotes commodities

f   denotes factors of production in the model and they are capital and labor. There is no skill disaggregation in the labor factor.

Note: In the TurkStat Input-Output tables sectors are divided into 64 commodities, but computational constraints tend to limit the number of goods and also regions. These details are already explained in former chapter.

Appendix D: Definition of activity levels and price variable.

Variable Name	Definition	GAMS variable
Y_{jr}	Production	Y(j,r)
C_r	Private Consumption	C(r)
G	Public Provision in National Level	G
YT_{mr}	Transport Services	YT(m,r)
A_{ir}	Armington Goods	A(i,r)
X_{ir}	Allocation of Production	X(i,r)
$invest_r$	Regional Investment	rinv(r)
p^G	Public Provision	PG
p_r^C	Final demand price index for priv. cons.	PC(i,r)
p_{jr}^Y	Domestic supply price	PD(j,r)
p_{ir}^I	Investment Price Index	PINV(r)
p_{ir}^A	Armington composite price index	PA(i,r)
p_{fr}^F	Price of primary factors	PF(i,r)
p_{ir}^{TR}	Interregional trade flow prices	PTR(i,r)

Appendix E: Project definitions and cumulative results by project order.

- Project 1: Istanbul – Izmir highway project including Izmit Bay Bridge
- Project 2: Istanbul – Tekirdag – Canakkale - Balikesir highway project including 1915 bridge connecting Canakkale to Tekirdag through hellespont
- Project 3: Ankara – Nevsehir – Nigde highway project
- Project 4: Silifke – Mersin and Antalya – Alanya highway project
- Project 5: Ankara – Izmir highway project
- Project 6: Rize – Mardin highway project
- Project 7: Bursa – Antalya highway project
- Project 8: Delice (Kirikkale) – Amasya –Samsun highway project
- Project 9: Gerede (Bolu) – Merzifon (Amasya) highway project
- Project 10: Amasya – Sivas –Erzurum – Igdir highway project

Note 1: Project 1 corresponds to experiment 1.

Note 2: Experiment 2 includes project number 2, 3, 4 and 5.

Note 3: Experiment 3 includes project number 6, 7, 8, 9 and 10.

Note 4: All maps and table below describes the model outputs at the cumulative level. Namely, following map and table illustrates the model results for the project number 1 + project number 2. Next one illustrates the model outputs for the project 1 + project 2 + project 3. All of these projects are targeted chronically by general directorate of highways.